

**JOHN DEERE**  
**WORLDWIDE COMMERCIAL & CONSUMER**  
**EQUIPMENT DIVISION**

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**John Deere Select Series™ Tractors**  
**X300 Series**

TM2308 JANUARY 2011

**TECHNICAL MANUAL**



**JOHN DEERE**

North American Version  
Litho In U.s.a.



# INTRODUCTION

## Manual Description

This technical manual is written for an experienced technician and contains sections that are specifically for this product. It is a part of a total product support program.

The manual is organized so that all the information on a particular system is kept together. The order of grouping is as follows:

- Table of Contents
- Specifications and Information
- Identification Numbers
- Tools and Materials
- Component Location
- Schematics and Harnesses
- Theory of Operation
- Operation and Diagnostics
- Diagnostics
- Tests and Adjustments
- Repair
- Other

***Note: Depending on the particular section or system being covered, not all of the above groups may be used.***

The bleed tabs for the pages of each section will align with the sections listed on this page. Page numbering is consecutive from the beginning of the Safety section through the last section.

We appreciate your input on this manual. If you find any errors or want to comment on the layout of the manual please contact us.

**Safety**

**Specifications and Information**

**Engine (FH491)**

**Engine (FH661 and FH721)**

**Engine - (FS541V)**

**Electrical**

**Power Train**

**Hydraulics**

**Steering**

**Attachments**

**Miscellaneous**

All information, illustrations and specifications in this manual are based on the latest information at the time of publication. The right is reserved to make changes at any time without notice.

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# SAFETY

## Recognize Safety Information



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This is the safety-alert symbol. When you see this symbol on your machine or in this manual, be alert to the potential for personal injury.

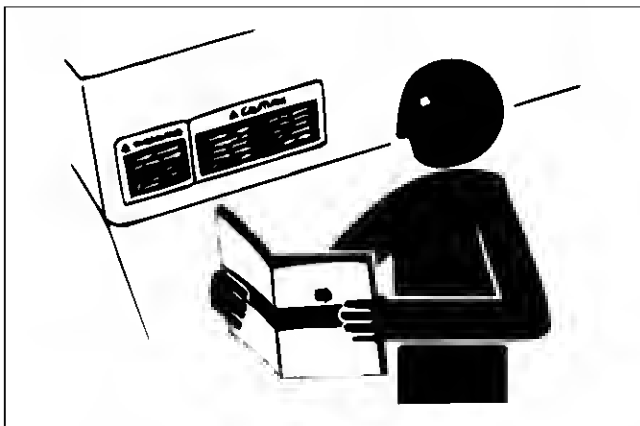
Follow recommended precautions and safe servicing practices.

## Understand Signal Words

A signal word - DANGER, WARNING, or CAUTION - is used with the safety-alert symbol. DANGER identifies the most serious hazards.

DANGER or WARNING safety signs are located near specific hazards. General precautions are listed on CAUTION safety signs. CAUTION also calls attention to safety messages in this manual.

## Replace Safety Signs

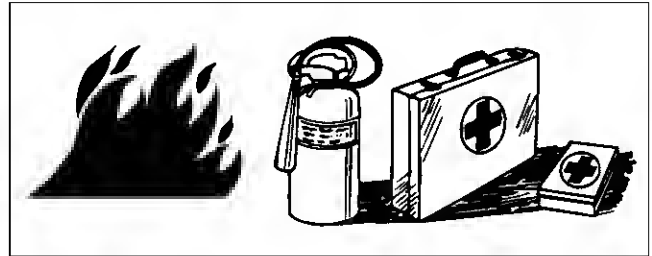


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Replace missing or damaged safety signs. See the machine operator's manual for correct safety sign placement.

## Handle Fluids Safely - Avoid Fires

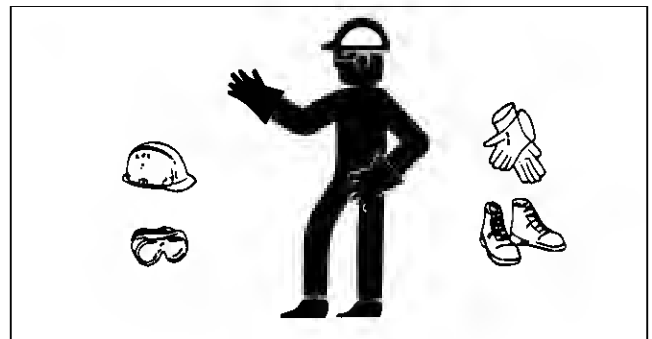
### Be Prepared For Emergencies



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- When you work around fuel, do not smoke or work near heaters or other fire hazards.
- Store flammable fluids away from fire hazards. Do not incinerate or puncture pressurized containers.
- Make sure machine is clean of trash, grease, and debris.
- Do not store oily rags; they can ignite and burn spontaneously.
- Be prepared if a fire starts.
- Keep a first aid kit and fire extinguisher handy.
- Keep emergency numbers for doctors, ambulance service, hospital, and fire department near your telephone.

## Wear Protective Clothing



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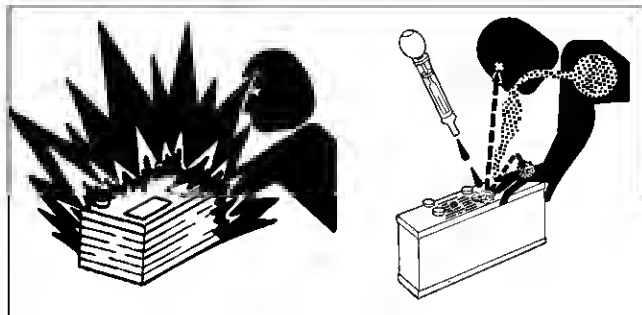
Wear close fitting clothing and safety equipment appropriate to the job.

Prolonged exposure to loud noise can cause impairment or loss of hearing. Wear a suitable hearing protective device such as earmuffs or earplugs to protect against objectionable or uncomfortable loud noises.

Operating equipment safely requires the full attention of the operator. Do not wear radio or music headphones while operating machine.

# SAFETY

## Use Care In Handling and Servicing Batteries



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### Prevent Battery Explosions

- Keep sparks, lighted matches, and open flame away from the top of battery. Battery gas can explode.
- Never check battery charge by placing a metal object across the posts. Use a volt-meter or hydrometer.
- Do not charge a frozen battery; it may explode. Warm battery to 16°C (60°F).

### Prevent Acid Burns

- Sulfuric acid in battery electrolyte is poisonous. It is strong enough to burn skin, eat holes in clothing, and cause blindness if splashed into eyes.

#### Avoid acid burns by:

1. Filling batteries in a well-ventilated area.
2. Wearing eye protection and rubber gloves.
3. Avoiding breathing fumes when electrolyte is added.
4. Avoiding spilling or dripping electrolyte.
5. Use proper jump start procedure.

#### If you spill acid on yourself:

1. Flush your skin with water.
2. Apply baking soda or lime to help neutralize the acid.
3. Flush your eyes with water for 10 - 15 minutes.
4. Get medical attention immediately.

#### If acid is swallowed:

1. Drink large amounts of water or milk.
2. Then drink milk of magnesia, beaten eggs, or vegetable oil.
3. Get medical attention immediately.

## Service Machines Safely

Tie long hair behind your head. Do not wear a necktie, scarf, loose clothing, or necklace when you work near machine tools or moving parts. If these items were to get caught, severe injury could result.

Remove rings and other jewelry to prevent electrical shorts and entanglement in moving parts.

### Use Proper Tools

Use tools appropriate to the work. Makeshift tools and procedures can create safety hazards. Use power tools only to loosen threaded parts and fasteners. For loosening and tightening hardware, use the correct size tools. **DO NOT** use U.S. measurement tools on metric fasteners. Avoid bodily injury caused by slipping wrenches. Use only service parts meeting John Deere specifications.

### Work In Clean Area

#### Before starting a job:

1. Clean work area and machine.
2. Make sure you have all necessary tools to do your job.
3. Have the right parts on hand.
4. Read all instructions thoroughly; do not attempt shortcuts.

### Illuminate Work Area Safely

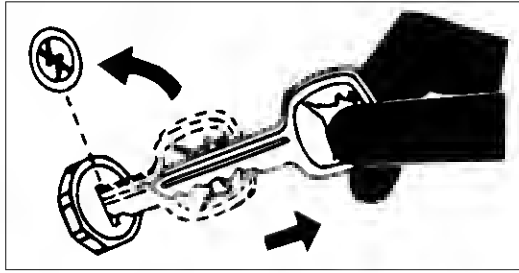
Illuminate your work area adequately but safely. Use a portable safety light for working inside or under the machine. Make sure the bulb is enclosed by a wire cage. The hot filament of an accidentally broken bulb can ignite spilled fuel or oil.

### Using High Pressure Washers

Directing pressurized water at electronic/electrical components or connectors, bearings, hydraulic seals, fuel injection pumps or other sensitive parts and components may cause product malfunctions. Reduce pressure and spray at a 45 to 90 degree angle.

# SAFETY

## Park Machine Safely

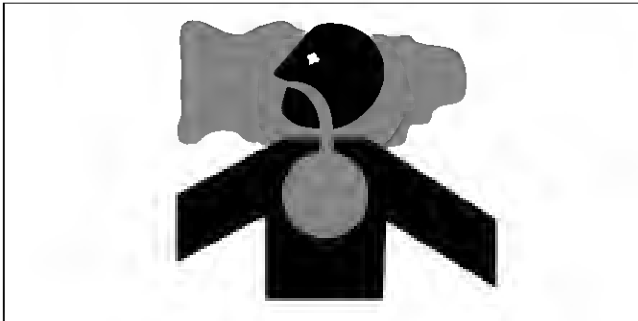


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### Before working on the machine:

1. Lower all equipment to the ground.
2. Lock the park brake.
3. Stop the engine and remove the key.
4. Disconnect the battery ground strap.
5. Hang a "DO NOT OPERATE" tag in operator station.

## Work In Ventilated Area



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Engine exhaust fumes can cause sickness or death. If it is necessary to run an engine in an enclosed area, remove the exhaust fumes from the area with an exhaust pipe extension.

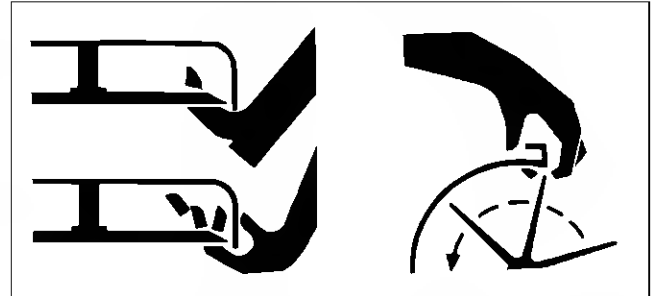
If you do not have an exhaust pipe extension, open the doors and get outside air into the area.

## Warning: California Proposition 65 Warning

Gasoline engine exhaust from this product contains chemicals known to the State of California to cause cancer, birth defects, or other reproductive harm.

Diesel engine exhaust and some of its constituents are known to the State of California to cause cancer, birth defects, and other reproductive harm.

## Avoid Injury From Rotating Blades and Shafts



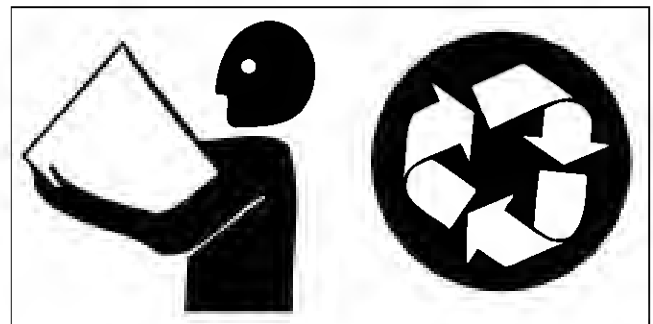
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Keep hands and feet away while machine is running. Shut off power to service, lubricate or remove mower blades, augers or PTO shafts.

## Dispose Of Waste Properly

Improperly disposing of waste can threaten the environment and ecology. Potentially harmful waste used with John Deere equipment include such items as oil, fuel, coolant, brake fluid, filters, and batteries. Use leakproof containers when draining fluids. Do not use food or beverage containers that may mislead someone into drinking from them. Do not pour waste onto the ground, down a drain, or into any water source. Inquire on the proper way to recycle or dispose of waste from your local environmental or recycling center, or from your John Deere dealer.

## Handle Chemical Products Safely



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Direct exposure to hazardous chemicals can cause serious injury. Potentially hazardous chemicals used with John Deere equipment include such items as lubricants, coolants, paints, and adhesives.

A Material Safety Data Sheet (MSDS) provides specific details on chemical products: physical and health hazards, safety procedures, and emergency response techniques. Check the MSDS before you start any job using a hazardous chemical. That way you will know exactly what the risks are and how to do the job safely. Then follow procedures and recommended equipment.

## Live With Safety



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Before returning machine to customer, make sure machine is functioning properly, especially the safety systems. Install all guards and shields.

# SPECIFICATIONS & INFORMATION TABLE OF CONTENTS

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## Table of Contents


























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# SPECIFICATIONS & INFORMATION GENERAL SPECIFICATIONS

## General Specifications

## Metric Fastener Torque Values

Property Class and Head Markings	<div>4.8</div> <div></div>	<div>8.89.8</div> <div></div>	<div>10.9</div> <div></div>	<div>12.9</div> <div></div>
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TS1163

TS1163

	Class 4.8				Class 8.8 or 9.8				Class 10.9				Class 12.9			
	Lubricated <sup>a</sup>		Dry <sup>a</sup>		Lubricated <sup>a</sup>		Dry <sup>a</sup>		Lubricated <sup>a</sup>		Dry <sup>a</sup>		Lubricated <sup>a</sup>		Dry <sup>a</sup>	
SIZE	N•m	lb-ft	N•m	lb-ft	N•m	lb-ft	N•m	lb-ft	N•m	lb-ft	N•m	lb-ft	N•m	lb-ft	N•m	lb-ft
M6	4.8	3.5	6	4.5	9	6.5	11	8.5	13	9.5	17	12	15	11.5	19	14.5
M8	12	8.5	15	11	22	16	28	20	32	24	40	30	37	28	47	35
M10	23	17	29	21	43	32	55	40	63	47	80	60	75	55	95	70
M12	40	29	50	37	75	55	95	70	110	80	140	105	130	95	165	120
M14	63	47	80	60	120	88	150	110	175	130	225	165	205	150	260	190
M16	100	73	125	92	190	140	240	175	275	200	350	225	320	240	400	300
M18	135	100	175	125	260	195	330	250	375	275	475	350	440	325	560	410
M20	190	140	240	180	375	275	475	350	530	400	675	500	625	460	800	580
M22	260	190	330	250	510	375	650	475	725	540	925	675	850	625	1075	800
M24	330	250	425	310	650	475	825	600	925	675	1150	850	1075	800	1350	1000
M27	490	360	625	450	950	700	1200	875	1350	1000	1700	1250	1600	1150	2000	1500
M30	675	490	850	625	1300	950	1650	1200	1850	1350	2300	1700	2150	1600	2700	2000
M33	900	675	1150	850	1750	1300	2200	1650	2500	1850	3150	2350	2900	2150	3700	2750
M36	1150	850	1450	1075	2250	1650	2850	2100	3200	2350	4050	3000	3750	2750	4750	3500

- DO NOT use these hand torque values if a different torque value or tightening procedure is given for a specific application. Torque values listed are for general use only and include a  $\pm 10\%$  variance factor. Check tightness of fasteners periodically. DO NOT use air powered wrenches.

- Shear bolts are designed to fail under predetermined loads. Always replace shear bolts with identical grade.
- Fasteners should be replaced with the same class. Make sure fastener threads are clean and that you properly start thread engagement. This will prevent them from failing when tightening.

- When bolt and nut combination fasteners are used,

torque values should be applied to the **NUT** instead of the bolt head.

- Tighten toothed or serrated-type lock nuts to the full torque value.

<sup>a</sup> "Lubricated" means coated with a lubricant such as engine oil, or fasteners with phosphate and oil coatings. "Dry" means plain or zinc plated (yellow dichromate—Specification JDS117) without any lubrication.

Reference: JDS-200

## SPECIFICATIONS & INFORMATION GENERAL SPECIFICATIONS

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### Metric Fastener Torque Values—Grade 7

Size	Steel or Gray Iron Torque	Aluminum Torque
	N•m (lb-ft)	N•m (lb-ft)
M6	11 (8)	8 (6)
M8	24 (18)	19 (14)
M10	52 (38)	41 (30)
M12	88 (65)	70 (52)
M14	138 (102)	111 (82)
M16	224 (165)	179 (132)



# SPECIFICATIONS & INFORMATION GENERAL SPECIFICATIONS

## Inch Fastener Torque Values

SAE Grade and Head Markings	1 or 2 <sup>b</sup> No Marks 	5 5.1 5.2   	8 8.2  
SAE Grade and Nut Markings	2 No Marks 	5  	8  

TS1162

TS1162

	Grade 1				Grade 2 <sup>b</sup>				Grade 5, 5.1 or 5.2				Grade 8 or 8.2			
	Lubricated <sup>a</sup>		Dry <sup>a</sup>		Lubricated <sup>a</sup>		Dry <sup>a</sup>		Lubricated <sup>a</sup>		Dry <sup>a</sup>		Lubricated <sup>a</sup>		Dry <sup>a</sup>	
SIZE	N•m	lb-ft	N•m	lb-ft	N•m	lb-ft	N•m	lb-ft	N•m	lb-ft	N•m	lb-ft	N•m	lb-ft	N•m	lb-ft
1/4	3.7	2.8	4.7	3.5	6	4.5	7.5	5.5	9.5	7	12	9	13.5	10	17	12.5
5/16	7.7	5.5	10	7	12	9	15	11	20	15	25	18	28	21	35	26
3/8	14	10	17	13	22	16	27	20	35	26	44	33	50	36	63	46
7/16	22	16	28	20	35	26	44	32	55	41	70	52	80	58	100	75
1/2	33	25	42	31	53	39	67	50	85	63	110	80	120	90	150	115
9/16	48	36	60	45	75	56	95	70	125	90	155	115	175	130	225	160
5/8	67	50	85	62	105	78	135	100	170	125	215	160	215	160	300	225
3/4	120	87	150	110	190	140	240	175	300	225	375	280	425	310	550	400
7/8	190	140	240	175	190	140	240	175	490	360	625	450	700	500	875	650
1	290	210	360	270	290	210	360	270	725	540	925	675	1050	750	1300	975
1-1/8	470	300	510	375	470	300	510	375	900	675	1150	850	1450	1075	1850	1350
1-1/4	570	425	725	530	570	425	725	530	1300	950	1650	1200	2050	1500	2600	1950
1-3/8	750	550	950	700	750	550	950	700	1700	1250	2150	1550	2700	2000	3400	2550
1-1/2	1000	725	1250	925	990	725	1250	930	2250	1650	2850	2100	3600	2650	4550	3350

• DO NOT use these hand torque values if a different torque value or tightening procedure is given for a specific application. Torque values listed are for general use only and include a  $\pm 10\%$  variance factor. Check tightness of fasteners periodically. DO NOT use air powered wrenches.

• Shear bolts are designed to fail under predetermined loads. Always replace shear bolts with identical grade.

• Fasteners should be replaced with the same class. Make sure fastener threads are clean and that you properly start thread engagement. This will prevent them from failing when tightening.

• When bolt and nut combination fasteners are used, torque values should be applied to the **NUT** instead of the bolt head.

• Tighten toothed or serrated-type lock nuts to the full torque value.

<sup>a</sup> “**Lubricated**” means coated with a lubricant such as engine oil, or fasteners with phosphate and oil coatings. “**Dry**” means plain or zinc plated (yellow dichromate—Specification JDS117) without any lubrication.

<sup>b</sup> “**Grade 2**” applies for hex cap screws (not hex bolts) up to 152 mm (6 in.) long “**Grade 1**” applies for hex cap screws over 152 mm (6 in.) long, and for all other types of bolts and screws of any length.

Reference: JDS-G200

## Gasket Sealant Application

### Cleaning:

Clean both surfaces that will be joined using 100% isopropyl alcohol. Wipe excess off with a clean cloth. Cleaner/degreaser can be substituted for isopropyl alcohol.

### How to Dispense/Apply/Assemble Gasket Sealants:

Dispense approximately 1 to 2 ounces of flexible form-in-place gasket on a clean sheet or table top. Avoid using excess amounts that may be exposed for long periods of time. This will help prevent contamination from surrounding atmosphere such as dust with metal content.

Using an ink roller or similar device, apply to one surface of the joint by loading the roller from a plastic sheet and transferring the material in a thin film to the joint. The application should be the thinnest film possible, but providing complete coverage. This can be judged by the appearance of the joint once it is put together. Excessive amounts of will cause incorrect bearing end play, extend cure time, and will cause runoff of the material. A small bead or buildup at the joint is permissible and indicates good dispersion through the joint. Excess can be wiped from the joint. Joining should take place within three minutes after sealant application.

Apply proper cap screw torque and sequence as applicable. Allow a minimum of 30 minutes before air test or adding oil for test stand usage.

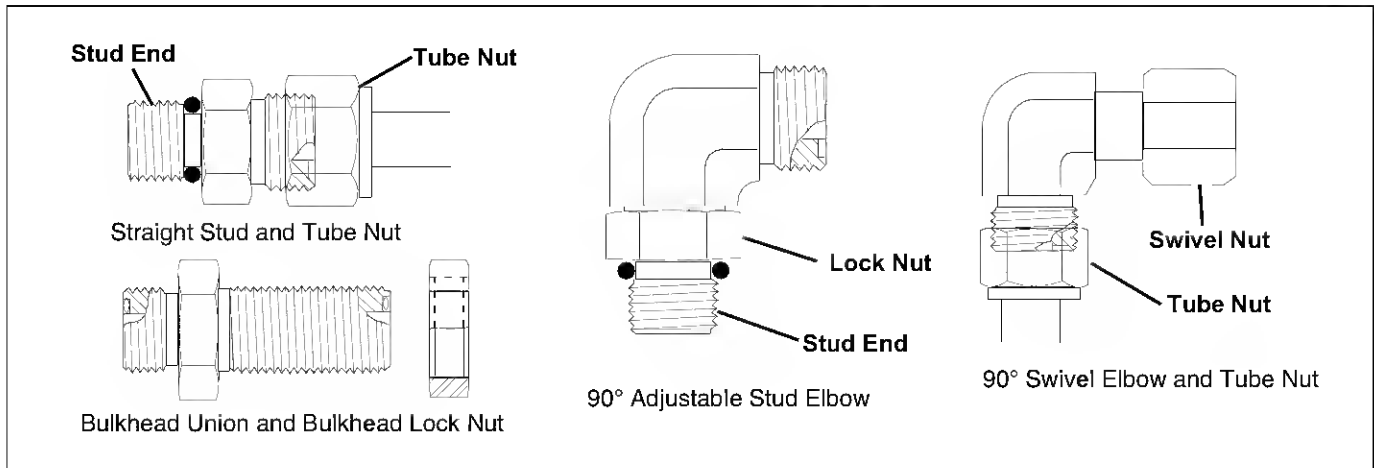
### Disassembly:

Cured material can be removed with a wire brush or scraper. Chemical cleaners are available for customer use, should they be deemed necessary.

# SPECIFICATIONS & INFORMATION O-RING SEAL SERVICE

## O-Ring Seal Service Recommendations

### Face Seal Fittings - Inch Stud Ends Torque



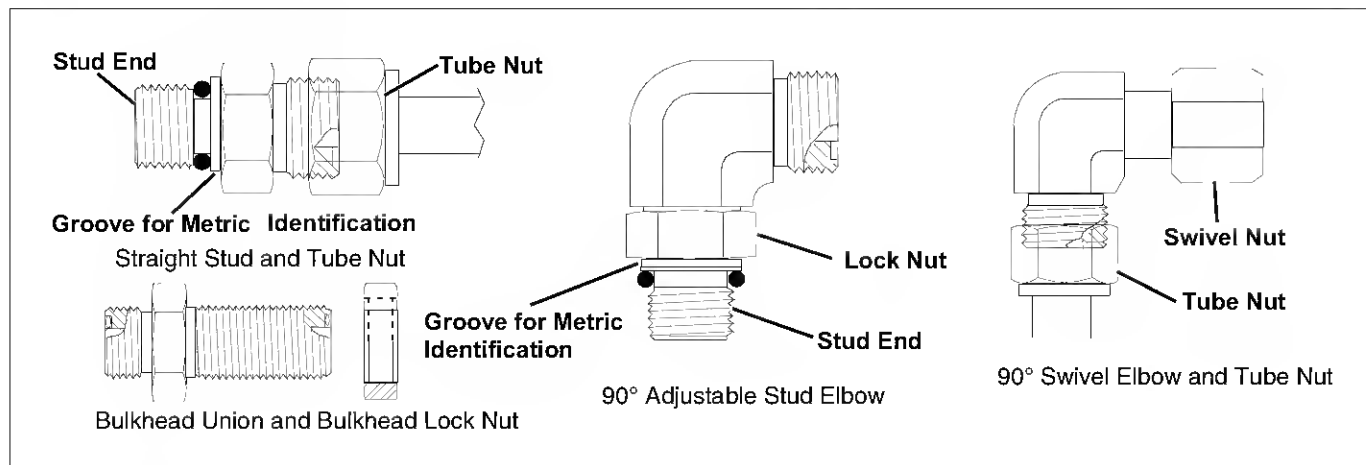
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Nominal Tube OD/Hose ID				Face Seal Tube/Hose End					O-Ring Stud Ends		
Metric Tube OD	Inch Tube OD			Thread Size	Tube Nut/ Swivel Nut Torque		Bulkhead Lock Nut Torque		Thread Size	Straight Fitting or Lock Nut Torque	
mm	Dash Size	in.	mm	in.	N•m	lb-ft	N•m	lb-ft	in.	N•m	lb-ft
	-3	0.188	4.76						3/8-24	8	6
6	-4	0.250	6.35	9/16-18	16	12	12	9	7/16-20	12	9
8	-5	0.312	7.94						1/2-20	16	12
10	-6	0.375	9.52	11/16-16	24	18	24	18	9/16-18	24	18
12	-8	0.500	12.70	13/16-16	50	37	46	34	3/4-16	46	34
16	-10	0.625	15.88	1-14	69	51	62	46	7/8-14	62	46
	-12	0.750	19.05	1-3/16-12	102	75	102	75	1-1/16-12	102	75
22	-14	0.875	22.22	1-3/16-12	102	75	102	75	1-3/16-12	122	90
25	-16	1.000	25.40	1-7/16-12	142	105	142	105	1-5/16-12	142	105
32	-20	1.25	31.75	1-11/16-12	190	140	190	140	1-5/8-12	190	140
38	-24	1.50	38.10	2-12	217	160	217	160	1-7/8-12	217	160

**Note: Torque tolerance is +15%, -20%**

# SPECIFICATIONS & INFORMATION O-RING SEAL SERVICE

## Face Seal Fittings - Metric Stud Ends Torque



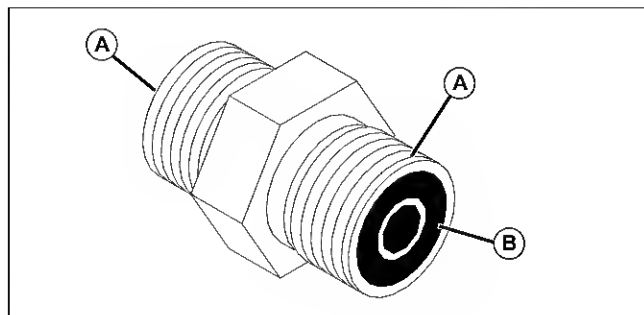
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Nominal Tube OD/Hose ID				Face Seal Tube/Hose End						O-Ring Stud Ends, Straight Fitting or Lock Nut					
Metric Tube OD	Inch Tube OD			Thread Size	Hex Size	Tube Nut/ Swivel Nut Torque		Bulkhead Lock Nut Torque		Thread Size	Hex Size	Steel or Gray Iron Torque		Aluminum Torque	
mm	Dash Size	in.	mm	in.	mm	N•m	lb-ft	N•m	lb-ft	mm	mm	N•m	lb-ft	N•m	lb-ft
6	-4	0.250	6.35	9/16-18	17	16	12	12	9	M12X1.5	17	21	15.5	9	6.6
8	-5	0.312	7.94												
										M14X1.5	19	33	24	15	11
10	-6	0.375	9.52	11/16-16	22	24	18	24	18	M16X1.5	22	41	30	18	13
12	-8	0.500	12.70	13/16-16	24	50	37	46	34	M18X1.5	24	50	37	21	15
16	-10	0.625	15.88	1-14	30	69	51	62	46	M22X1.5	27	69	51	28	21
	-12	0.750	19.05	1-3/16-12	36	102	75	102	75	M27X2	32	102	75	46	34
22	-14	0.875	22.22	1-3/16-12	36	102	75	102	75	M30X2	36				
25	-16	1.000	25.40	1-7/16-12	41	142	105	142	105	M33X2	41	158	116	71	52
28										M38X2	46	176	130	79	58
32	-20	1.25	31.75	1-11/16-12	50	190	140	190	140	M42X2	50	190	140	85	63
38	-24	1.50	38.10	2-12	60	217	160	217	160	M48X2	55	217	160	98	72

**Note: Torque tolerance is +15%, -20%**

# SPECIFICATIONS & INFORMATION O-RING SEAL SERVICE

## O-Ring Face Seal Fittings



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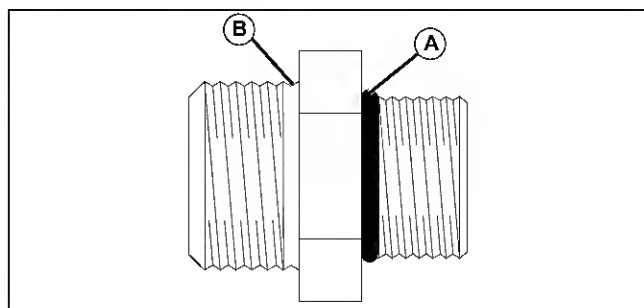
1. Inspect the fitting sealing surfaces (A). They must be free of dirt or defects.
2. Inspect the O-ring (B). It must be free of damage or defects.
3. Lubricate O-rings and install into groove using petroleum jelly to hold in place.
4. Push O-ring into the groove with plenty of petroleum jelly so O-ring is not displaced during assembly.
5. Index angle fittings and tighten by hand-pressing joint together to ensure O-ring remains in place.

**Important: Avoid Damage! DO NOT allow hoses to twist when tightening fittings. Use two wrenches to tighten hose connections; one to hold the hose, and the other to tighten the swivel fitting.**

6. Tighten fitting or nut to torque value shown on the chart per dash size stamped on the fitting.

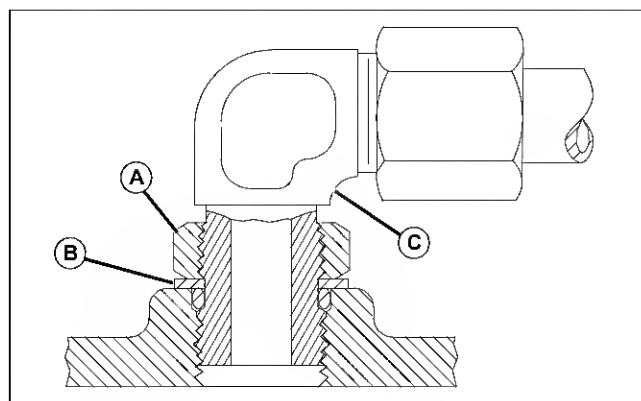
## O-Ring Boss Fittings

1. Inspect boss O-ring boss seat. It must be free of dirt and defects. If repeated leaks occur, inspect for defects with a magnifying glass. Some raised defects can be removed with a slip stone.



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2. Put hydraulic oil or petroleum jelly on the O-ring (A). Place electrical tape over the threads to protect O-ring from nicks. Slide O-ring over the tape and into the groove (B) of fitting. Remove tape.



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3. For angle fittings, loosen special nut (A) and push special washer (B) against threads so O-ring can be installed into the groove of fitting.
4. Turn fitting into the boss by hand until special washer or washer face (straight fitting) contacts boss face and O-ring is squeezed into its seat.
5. To position angle fittings (C), turn the fitting counter-clockwise a maximum of one turn.
6. Tighten straight fittings to torque value shown on chart. For angle fittings, tighten the special nut to value shown in the chart while holding body of fitting with a wrench.

Thread Size	Torque <sup>a</sup>		Number of Flats <sup>b</sup>
	N•m	lb-ft	
3/8-24 UNF	8	6	2
7/16-20 UNF	12	9	2
1/2-20 UNF	16	12	2
9/16-18 UNF	24	18	2
3/4-16 UNF	46	34	2
7/8-14 UNF	62	46	1-1/2
1-1/16-12 UN	102	75	1
1-3/16-12 UN	122	90	1
1-5/16-12 UN	142	105	3/4
1-5/8-12 UN	190	140	3/4
1-7/8-12 UN	217	160	1/2

<sup>a</sup>Torque tolerance is  $\pm 10$  percent.

<sup>b</sup>To be used if a torque wrench cannot be used. After tightening fitting by hand, put a mark on nut or boss; then tighten special nut or straight fitting the number of flats shown.

## Fuels and Lubricants

### Gasoline



**Caution: Avoid Injury! Gasoline is HIGHLY FLAMMABLE**, handle it with care. **DO NOT** refuel machine while:

indoors, always fill gas tank outdoors  
machine is near an open flame or sparks  
engine is running, **STOP** engine  
engine is hot, allow it to cool sufficiently first  
smoking

**Help prevent fires:**

fill gas tank to bottom of filler neck only  
be sure fill cap is tight after fueling

clean up any gas spills **IMMEDIATELY**

keep machine clean and in good repair-free of excess grease, oil, debris, and faulty or damaged parts

any storage of machines with gas left in tank should be in an area that is well ventilated to prevent possible igniting of fumes by an open flame or spark, this includes any appliance with a pilot light

To prevent fire or explosion caused by **STATIC ELECTRIC DISCHARGE** during fueling:

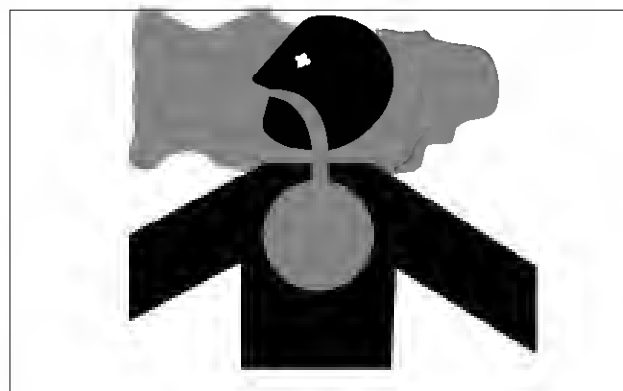
**ONLY** use a clean, approved **POLYETHYLENE PLASTIC** fuel container and funnel **WITHOUT** any metal screen or filter

To avoid engine damage:

- **DO NOT** mix oil with gasoline
- **ONLY** use clean, fresh unleaded gasoline with an octane rating (anti-knock index) of 87 or higher
- fill gas tank at the end of each day's operation to help prevent condensation from forming inside a partially filled tank
- keep up with specified service intervals

Use of alternative oxygenated, gasohol blended, unleaded gasoline is acceptable as long as:

- the ethyl or grain alcohol blends **DO NOT** exceed 10% by volume or



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- methyl tertiary butyl ether (MTBE) blends **DO NOT** exceed 15% by volume

**Important: Avoid Damage! DO NOT use METHANOL** gasolines because **METHANOL** is harmful to the environment and to your health.



**Caution: Avoid Injury! California Proposition 65 Warning: Gasoline engine exhaust from this product contains chemicals known to the State of California to cause cancer, birth defects, or other reproductive harm.**

### Gasoline Storage

**Important: Avoid Damage! Keep all dirt, scale, water or other foreign material out of gasoline.**

Keep gasoline stored in a safe, protected area. Storage of gasoline in a clean, properly marked ("UNLEADED GASOLINE") **POLYETHYLENE PLASTIC** container **WITHOUT** any metal screen or filter is recommended. **DO NOT** use de-icers to attempt to remove water from gasoline or depend on fuel filters to remove water from gasoline. Use a water separator installed in the storage tank outlet. **BE SURE** to properly discard unstable or contaminated gasoline. When storing machine or gasoline, it is recommended that you add **John Deere Gasoline Conditioner and Stabilizer (TY15977)** or an equivalent to the gasoline. **BE SURE** to follow directions on container and to properly discard empty container.

# SPECIFICATIONS & INFORMATION FUELS AND LUBRICANTS

## Engine Oil

Use the appropriate oil viscosity based on the expected air temperature range during the period between recommended oil changes. Operating outside of these recommended oil air temperature ranges may cause premature engine failure.

The following John Deere oils are **PREFERRED**:

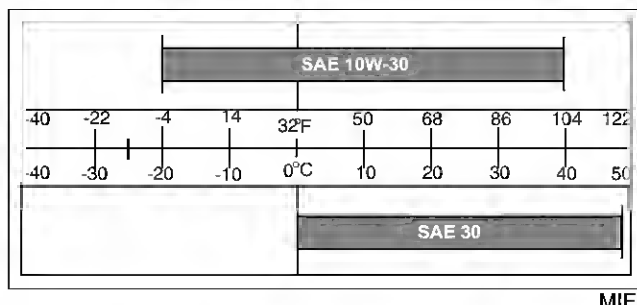
- **TURF-GARD™ - SAE 10W-30;**
- **PLUS-4™ - SAE 10W-30;**

The following John Deere oils are **also recommended**, based on their specified temperature range:

- **TORQ-GARD SUPREME™ - SAE 30;**

Other oils may be used if above John Deere oils are not available, provided they meet one of the following specifications:

- SAE 30 - API Service Classification SJ or higher;
- SAE 10W-30 - API Service Classification SJ or higher;



## Engine Break-in Oil

**Important: Avoid Damage! ONLY use a quality break-in oil in rebuilt or remanufactured engines for the first 5 hours (maximum) of operation. DO NOT use oils with heavier viscosity weights than SAE 5W-30 or oils meeting specifications API SG or SH, these oils will not allow rebuilt or remanufactured engines to break-in properly.**

The following John Deere oil is **PREFERRED**:

- **BREAK-IN ENGINE OIL.**

John Deere BREAK-IN ENGINE OIL is formulated with special additives for aluminum and cast iron type engines to allow the power cylinder components (pistons, rings, and liners as well) to "wear-in" while protecting other engine components, valve train and gears, from abnormal wear. Engine rebuild instructions should be followed closely to determine if special requirements are necessary.

John Deere BREAK-IN ENGINE OIL is also recommended for non-John Deere engines, both aluminum and cast iron types.

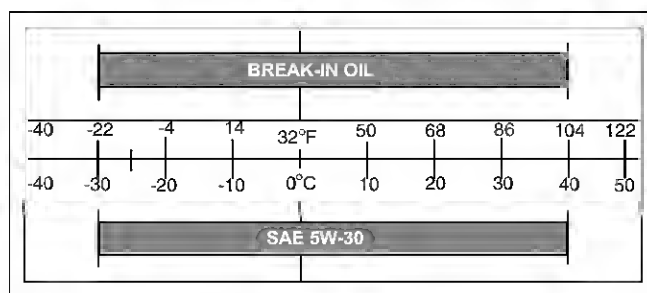
The following John Deere oil is **also recommended** as a **break-in engine oil**:

- **TORQ-GARD SUPREME®—SAE 5W-30.**

If the above recommended John Deere oils are not available, use a break-in engine oil meeting the following specification during the first 5 hours (maximum) of operation:

- SAE 5W-30—API Service Classification SE or higher.

**Important: Avoid Damage! After the break-in period, use the John Deere oil that is recommended for this engine.**



## Alternative Lubricants

Conditions in certain geographical areas outside the United States and Canada may require different lubricant recommendations than the ones printed in this technical manual or the operator's manual. Consult with your John Deere Dealer, or Sales Branch, to obtain the alternative lubricant recommendations.

**Important: Avoid Damage! Use of alternative lubricants could cause reduced life of the component.**

If alternative lubricants are to be used, it is recommended that the factory fill be thoroughly removed before switching to any alternative lubricant.

## Synthetic Lubricants

Synthetic lubricants may be used in John Deere equipment if they meet the applicable performance requirements (industry classification and/or military specification) as shown in this manual.

The recommended air temperature limits and service or lubricant change intervals should be maintained as shown in the operator's manual.

Avoid mixing different brands, grades, or types of oil. Oil manufacturers blend additives in their oils to meet certain specifications and performance requirements. Mixing different oils can interfere with the proper functioning of

# SPECIFICATIONS & INFORMATION FUELS AND LUBRICANTS

these additives and degrade lubricant performance.

## Lubricant Storage

All machines operate at top efficiency only when clean lubricants are used. Use clean storage containers to handle all lubricants. Store them in an area protected from dust, moisture, and other contamination. Store drums on their sides. Make sure all containers are properly marked as to their contents. Dispose of all old, used containers and their contents properly.

## Mixing Of Lubricants

In general, avoid mixing different brands or types of lubricants. Manufacturers blend additives in their lubricants to meet certain specifications and performance requirements. Mixing different lubricants can interfere with the proper functioning of these additives and lubricant properties which will downgrade their intended specified performance.

## Chassis Grease

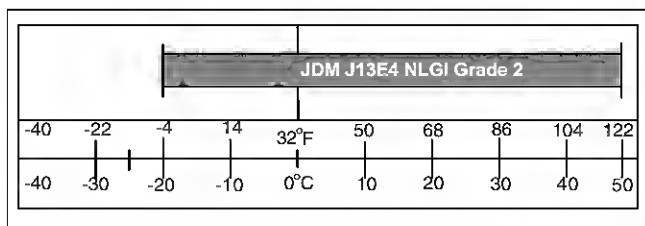
Use the following grease based on the air temperature range. Operating outside of the recommended grease air temperature range may cause premature failures.

The following John Deere grease is **PREFERRED**:

- **NON-CLAY HIGH-TEMPERATURE EP GREASE®—JDM J13E4, NLGI Grade 2.**
- Multi-Purpose SD Polyurea Grease
- Multi-Purpose HD Lithium Complex Grease

Other greases may be used if above preferred John Deere grease is not available, provided they meet the following specification:

- John Deere Standard JDM J13E4, NLGI Grade 2.



## Mower Spindle Grease

This premium, multi-purpose grease is specially formulated as a high-temperature, extreme-pressure grease, especially effective in rolling contact applications.

The following water resistant grease is **preferred**:

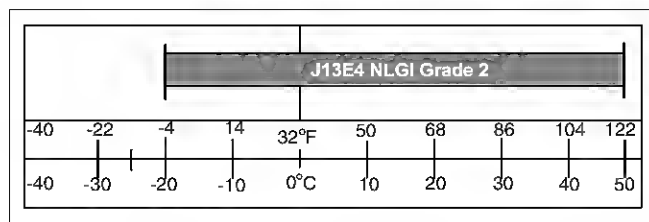
- Multi-Purpose SD Polyurea Grease - TY6341.

The following multi-purpose grease may also be used:

- Multi-Purpose HD Lithium Complex Grease - TY24416.

Other greases may be used if they meet or exceed the following specification:

- John Deere Standard JDM J13E4, NLGI Grade 2.



## Transaxle Oil - K46 and K58 Transaxles

These machines are equipped with a internal wet disc brake transmission (Hydrostatic transmission).

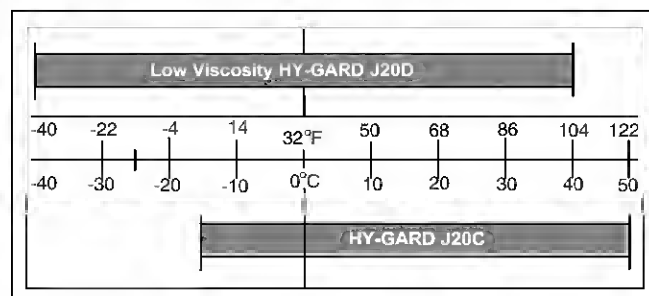
**Important: Avoid Damage! Use ONLY the following oils for service. DO NOT use automatic transmission fluid.**

**Note: The K46 and K58 transaxles (without power steering or attachment lift cylinders) are filled with 10W30 engine oil at the factory.**

**For the transaxles used in extreme or high-hour applications, J20C Hygard Hydraulic oil or 5W-50 Synthetic Engine Oil is approved as an optional fill. Use only after a complete drain of the factory oil.**

## Transaxle Oil - K58H Transaxle

These machines are equipped with an internal wet disc brake transmission.





## SPECIFICATIONS & INFORMATION SERIAL NUMBER LOCATIONS

Use the appropriate oil viscosity based on these air temperature ranges. Operating outside of these recommended oil air temperature ranges may cause premature hydrostatic transmission or hydraulic system failures.

**Important: Avoid Damage! Mixing of LOW VISCOSITY HY - GARD™ and HY - GARD™ oils is permitted. DO NOT mix any other oils in this transmission. DO NOT use engine oil or “Type F” (Red) Automatic Transmission Fluid in this transmission.**

John Deere J20D Low Viscosity transmission and hydraulic oil is recommended. John Deere John Deere J20C HY-GARD™ transmission and hydraulic oil may be used, if within the specified temperature range.

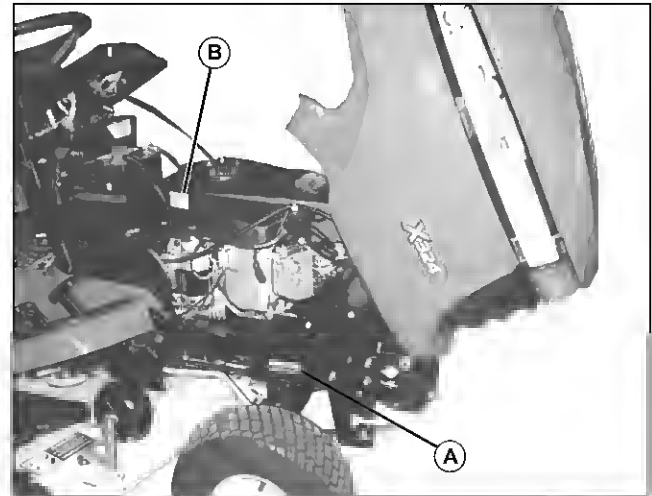
Other oils may be used if above recommended John Deere oils are not available, provided they meet one of the following specifications:

- John Deere Standard JDM J20D;
- John Deere Standard JDM J20C.

### Serial Number Locations

#### Product Identification Numbers

When ordering parts or submitting a warranty claim, it is **IMPORTANT** that the machine product identification number (PIN) and component serial numbers are included. The location of the PIN and component serial numbers are shown.



MX36205

The machine identification (A) is located on right side of frame.

The engine identification number (B) is located on the engine housing.

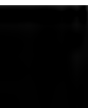


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# ENGINE - KAWASAKI (FH491V) SPECIFICATIONS

## Specifications

### General Specifications

#### General Specifications:

Engine Use	X300 and X304
Make	Kawasaki V-Twin
Model Number	FH491V
Bore	68 mm (2.68 in.)
Stroke	65 mm (2.56 in.)
Displacement	472cm <sup>3</sup> (28.8 cu in.)
Cylinders	2 (V-Twin)
Stroke Cycle	4
Valves	Overhead
Lubrication	Fully Pressurized
Oil Capacity w/ Oil Filter	1.8 L (1.9 qt)
Oil Filter	Single Element, Full Flow, Spin-On
Cooling System	Air
Muffler	Horizontal Discharge Below Frame
Spark Plug Gap	0.76 mm (0.030 in.)
Spark Plug Torque	22 N·m (195 lb-in.)

### Test and Adjustment Specifications

#### Test and Adjustment Specifications:

Governed Low Idle	1850 ± 100 rpm
Fast Idle	3350 ± 100 rpm
Low Speed Carb Idle Screw	1450 ± 100 rpm
Ignition Coil Air Gap	0.25 - 0.40 mm (0.010 - 0.016 in.)
Oil Pressure @ 3000 rpm	240 - 310 kPa (35 - 45 psi)
Crankcase Vacuum	1.3 - 25.4 cm (0.5 - 10.0 in.)
Cylinder Compression (Minimum)	390 kPa (57 psi)
Valve Clearance (Intake and Exhaust) (Cold)	0.075 - 0.125 mm (0.003 - 0.005 in.)
Fuel Pump Pressure (Slow Idle)	2.45 kPa (0.36 psi)
Minimum Fuel Flow	65 mL (2.2 oz)/15 seconds

### Repair Specifications

#### Cylinder Head:

Cylinder Head Distortion (Maximum)	0.03 mm (0.001 in.)
Valve Guides ID	6.00 - 6.01 mm (0.0236 - 0.237 in.)
Valve Guides ID (Maximum)	6.08 mm (0.239 in.)
Valve Seat Width	0.6 - 0.9 mm (0.024 - 0.035 in.)
Valve Spring Free Length	31.0 mm (1.22 in.)

#### Intake and Exhaust Valves:

Valve Clearance (Intake and Exhaust) (Cold)	0.075 - 0.125 mm (0.003 - 0.005 in.)
Valve Stem OD (Intake) (Minimum)	5.93 mm (0.233 in.)

# ENGINE - KAWASAKI (FH491V) SPECIFICATIONS

Valve Stem OD (Exhaust) (Minimum) . . . . .	5.93 mm (0.233 in.)
Valve Stem Bend (Maximum) . . . . .	0.03 mm (0.001 in.)
Valve Guide ID (Standard) . . . . .	6.00 - 6.012 mm (0.236 - 0.237 in.)
Valve Guide ID (Maximum) . . . . .	6.08 mm (0.239 in.)
Valve Seating Surface (Standard) . . . . .	0.60 - 0.90 mm (0.024 - 0.035 in.)
Valve Seat and Face Angle . . . . .	45°
Valve Margin (Minimum) . . . . .	0.35 mm (0.014 in.)
Valve Seat Narrowing Angle . . . . .	32°

## Piston Assembly:

Piston Ring Side Clearance (Top Ring) . . . . .	0.15 mm (0.006 in.)
Piston Ring Side Clearance (Second Ring) . . . . .	0.12 mm (0.005 in.)
Piston Ring Side Clearance (Oil Ring) . . . . .	Not Measured
Piston Ring Thickness (Top and Second) . . . . .	1.40 mm (0.055 in.)
Piston Ring End Gap Maximum (Top Ring) . . . . .	0.70 mm (0.028 in.)
Piston Ring End Gap Maximum (Second Ring) . . . . .	0.78 mm (0.031 in.)
Piston Ring End Gap Maximum (Oil Ring) . . . . .	1.05 mm (0.041 in.)
Piston Pin OD (Minimum) . . . . .	15.96 mm (0.628 in.)
Piston Pin Bore OD (Maximum) . . . . .	16.08 mm (0.633 in.)
Piston OD (Standard Minimum) . . . . .	67.79 mm (2.669 in.)
Piston OD (Oversize 0.50 mm (0.020 in.) . . . . .	68.29 mm (2.689 in.)
Piston-to-Cylinder Bore Clearance . . . . .	0.015 - 0.15 mm (0.001 - 0.006 in.)
Cylinder Bore ID (Standard) . . . . .	67.98 - 68.00 mm (2.676 - 2.677 in.)
Cylinder Bore ID (Wear Limit) . . . . .	68.10 mm (2.681 in.)
Cylinder Bore ID (Oversize 0.50 mm (0.020 in.)) . . . . .	68.48 - 68.50 mm (2.696 - 2.697 in.)
Cylinder Bore ID (Oversize 0.50 mm (0.020 in.) Wear Limit) . . . . .	68.60 mm (2.701 in.)

## Connecting Rod:

Crankshaft Bearing ID (Maximum) . . . . .	35.06 mm (1.380 in.)
Piston Pin Bearing ID (Maximum) . . . . .	16.05 mm (0.632 in.)

## Crankshaft:

Crankpin Width (Maximum) . . . . .	39.50 mm (1.380 in.)
Crankpin OD (Minimum) . . . . .	34.94 mm (1.376 in.)
Journal Diameter (PTO Side) (Minimum) . . . . .	34.90 mm (1.374 in.)
Journal Diameter (Flywheel Side) (Minimum) . . . . .	34.93 mm (1.375 in.)
Crankcase Cover PTO Shaft ID (Maximum) . . . . .	35.15 mm (1.384 in.)
Crankcase Crankshaft Journal Bearing ID (Maximum) . . . . .	35.15 mm (1.384 in.)

## Camshaft:

Lobe Height (Intake and Exhaust) (Minimum) . . . . .	29.13 mm (1.147 in.)
Journal Diameter (PTO and Flywheel) (Minimum) . . . . .	15.99 mm (0.629 in.)
Bearing ID (Crankcase and Cover) (Maximum) . . . . .	16.14 mm (0.635 in.)

## Oil Pump:

Rotor Shaft OD (Minimum) . . . . .	10.92 mm (0.430 in.)
Rotor Shaft Bearing ID (Maximum) . . . . .	11.07 mm (0.436 in.)
Outer Rotor OD (Minimum) . . . . .	40.47 mm (1.593 in.)
Outer Rotor Bearing ID (Maximum) . . . . .	40.80 mm (1.606 in.)

# ENGINE - KAWASAKI (FH491V) SPECIFICATIONS

Outer Rotor Thickness (Minimum) .....	9.83 mm (0.387 in.)
Inner and Outer Rotor Clearance (Maximum) .....	0.2 mm (0.008 in.)
Pump Housing Depth (Maximum) .....	10.23 mm (0.403 in.)
Spring Free Length (Minimum) .....	19.5 mm (0.768 in.)
Oil Pressure Sensor Continuity (On) .....	98 kPa (14.2 psi)
Oil Filter Bypass Valve Opening Pressure .....	78.5 - 117.5 kPa (11.4 - 17.1 psi)

## Starting Motor:

Maximum Amperage (No Load) .....	50 amps @ 6000 rpm
Brush Length (Minimum) .....	6.4 mm (0.25 in.)

## Torque Specifications

### Torque Specifications:

Breather Cover Cap Screws .....	6.9 N•m (61 lb-in.)
Carburetor Mounting Stud Nut .....	6.9 N•m (61 lb-in.)
Connecting Rod Cap Screw .....	5.9 N•m (52 lb-in.)
Cooling Shroud Mounting Cap Screws .....	5.9 N•m (52 lb-in.)
Cylinder Head Cap Screws (Initial Torque) .....	13 N•m (115 lb-in.)
Cylinder Head Cap Screws (Final Torque) .....	25 N•m (221 lb-in.)
Crankcase Cover Mounting Cap Screws .....	25 N•m (221 lb-in.)
Engine Mounting Cap Screws .....	34 N•m (25 lb-ft)
Exhaust Pipe Nuts .....	22 N•m (16 lb-ft)
Fan Housing Cap Screws .....	5.9 N•m (52 lb-in.)
Flywheel Cap Screw .....	56 N•m (41 lb-ft)
Fuel Pump Mounting Cap Screws .....	5.9 N•m (52 lb-in.)
Fuel Solenoid to Carburetor .....	6.9 N•m (61 lb-in.)
Governor Arm Clamp Nut .....	7.8 N•m (69 lb-in.)
Governor Shaft Plate Screws .....	2 N•m (17 lb-in.)
Ignition Coil Cap Screws .....	7.8 N•m (69 lb-in.)
Intake Manifold Cap Screws (Initial Torque) .....	3 N•m (27 lb-in.)
Intake Manifold Cap Screws (Final Torque) .....	6.9 N•m (61 lb-in.)
Oil Plug .....	6.9 N•m (61 lb-in.)
Oil Pump Cover Cap Screws .....	5.9 N•m (52 lb-in.)
Rocker Arm Stud Bolts .....	28 N•m (247 lb-in.)
Rocker Cover Cap Screws .....	6.9 N•m (61 lb-in.)
Spark Plug Torque .....	22 N•m (16 lb-ft)
Starting Motor Mounting Cap Screws .....	15 N•m (133 lb-in.)
Stator Coil Cap Screws .....	3.9 N•m (35 lb-in.)

# ENGINE - KAWASAKI (FH491V) SPECIFICATIONS

## Tools

**Note:** Order tools according to information given in the **U.S. SERVICE-GARD™ Catalog** or in the **European Microfiche Tool Catalog (MTC)**.

### Special or Required Tools

Tool Name	Tool No.	Tool Use
Hand-Held Digital Tachometer	JT05719	Used to check idle speed and starter performance.
Digital Pulse Tachometer	JT07270	Used to check idle speed and starter performance.
Compression Gauge	JDM59	Used to check engine compression.
U-Tube Manometer Test Kit	JT05698	Used to check engine crankcase vacuum.
Vacuum Gauge	JT03503	Used to check engine crankcase vacuum.
Drill Bit	6.4 mm (0.25 in.)	Throttle adjustment.
Lapping Tool	- - -	Valve lapping
Dial Indicator	- - -	Automatic compression relief test, valve inspection, crankshaft end play.
Spark Plug Ground	JDM74A5	Used to prevent accidental engine starting during tests.
Reaming Tool (7.05 mm)	D20020W1	Clean or size valve guide.
Reaming Tool (7.25 mm)	D20020W1	Clean or size oversize valve guide.
90° Elbow Fitting Hose Assembly	JT03338 JT03017	Used to connect pressure gauge to engine when performing engine oil pressure test.
Pressure Gauge Assembly	JT03344	Used to read engine oil pressure when performing engine oil pressure test.
Pressure Gauge	JDG356	Used to check fuel pump performance.

## Special or Required Tools

Tool Name	Tool No.	Tool Use
Spark Tester	D-05351ST	Used to check overall condition of ignition system.
Valve Spring Compressor	JDM70	Used to remove and install valve springs.
Current Gun	JT05712	Used to check starter performance.

## Other Materials

### Other Material

Part No.	Part Name	Part Use
TY24416	Multipurpose Lithium Grease	Apply to engine crankshaft
	SCOTCH-BRITE® Abrasive Sheets/Pads	Clean cylinder head
	Valve Guide Cleaner	Clean valve guides
	Prussian Blue Compound	Check valve seat contact
TY24416	Lithium Base Grease	Pack oil seals
	Zinc Oxide/Wood Alcohol	Check block for cracks
	Mineral Spirits	Clean armature
	Valve Lap Compound	Lap valves
PM37418 LOCTITE 242	Thread Lock and Sealer (Medium Strength)	Apply to threads of throttle and choke plate screws
PM37565 LOCTITE 587 Canada PM38616	RTV Silicone Form-in-Place Gasket	Rocker arm cover mating surfaces
PM37397 LOCTITE 592	Thread Sealant (General Purpose) with TEFLON	Apply to threads of pipe plugs

LOCTITE is a registered trademark of the Loctite Corp.

SCOTCH-BRITE is a registered trademark of the 3M Co.

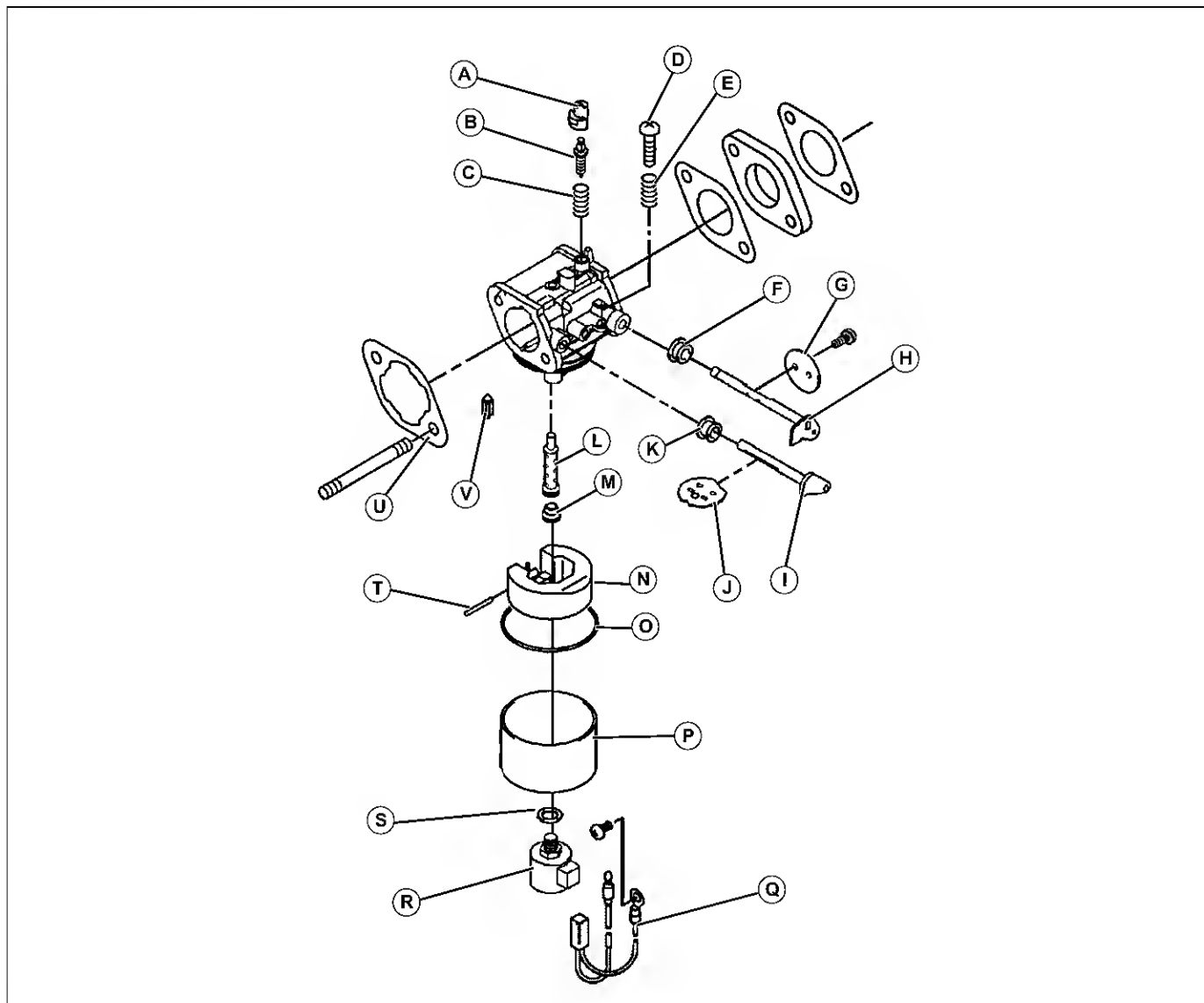
TEFLON® is a registered trademark of DuPont.



# ENGINE - KAWASAKI (FH491V) COMPONENT LOCATION

## Component Location

### Carburetor Components

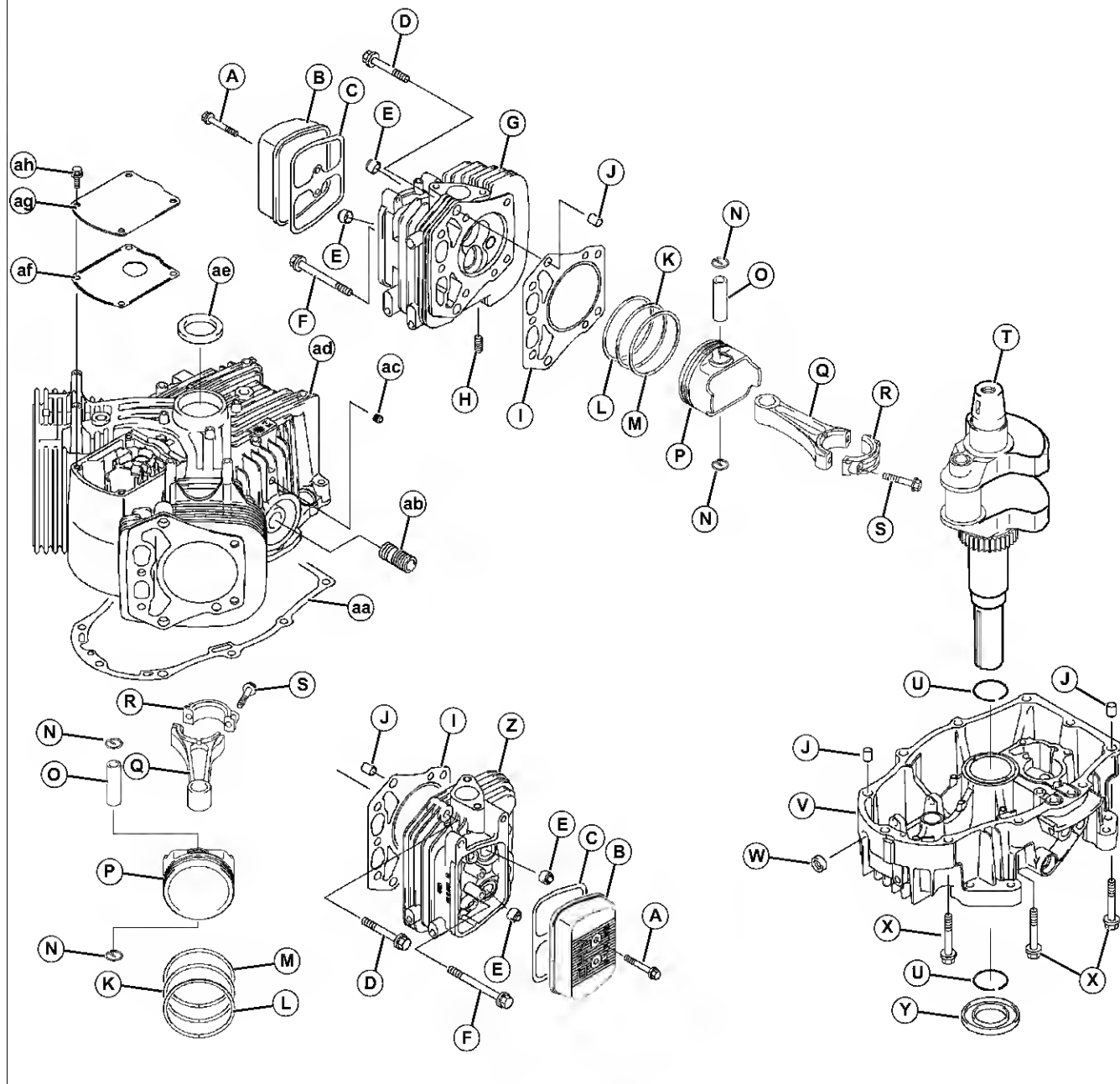


- A- Limiter
- B- Pilot Air Screw
- C- Spring
- D- Low Idle Screw
- E- Spring
- F- Seal
- G- Throttle Valve
- H- Throttle Shaft
- I- Choke Shaft
- J- Choke Valve
- K- Seal
- L- Main Nozzle

- M- Valve Seat
- N- Float
- O- Gasket
- P- Float Bowl
- Q- Solenoid Harness
- R- Fuel Solenoid
- S- Gasket
- T- Pin
- U- Gasket
- V- Float Valve

# ENGINE - KAWASAKI (FH491V) COMPONENT LOCATION

## Engine Block



MX39857

- A- Cap Screw M6x12 (4 used)
- B- Valve Cover
- C- Gasket
- D- Bolt (17 used)
- E- Seal
- F- Bolt (2 used)
- G- Cylinder Head No. 1
- H- Stud (4 used)
- I- Head Gasket
- J- Pin (6 used)

- K- Piston Ring, Compression
- L- Piston Ring, Chrome Compression
- M- Piston Ring, Oil Ring Assembly
- N- Snap Ring
- O- Piston Pin
- P- Piston
- Q- Connecting Rod
- R- Connecting Rod Cap
- S- Cap Screw M6x30
- T- Crankshaft
- U- Clip

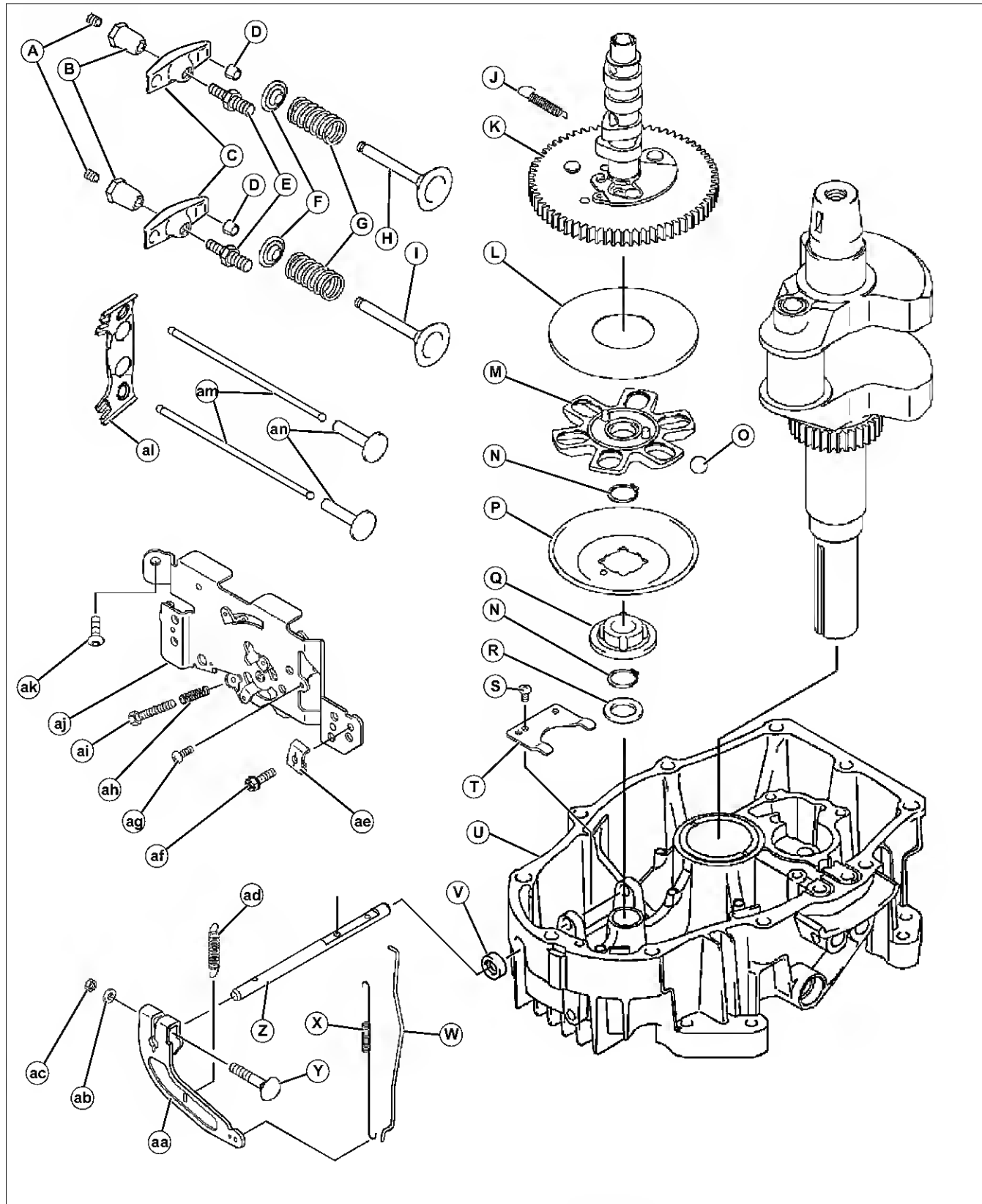
## ENGINE - KAWASAKI (FH491V) COMPONENT LOCATION

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V- Crankcase Cover  
W- Seal  
X- Bolt  
Y- Seal  
Z- Cylinder Head No. 2  
AA- Gasket  
AB- Fitting  
AC- Plug  
AD- Crankcase  
AE- Seal  
AF- Gasket  
AG- Cover  
AH- Screw M6x12

# ENGINE - KAWASAKI (FH491V) COMPONENT LOCATION

## Engine Valves and Governor



MX37029

A- Lock Screw  
B- Rocker Nut

C- Rocker Arm  
D- Spring Collet

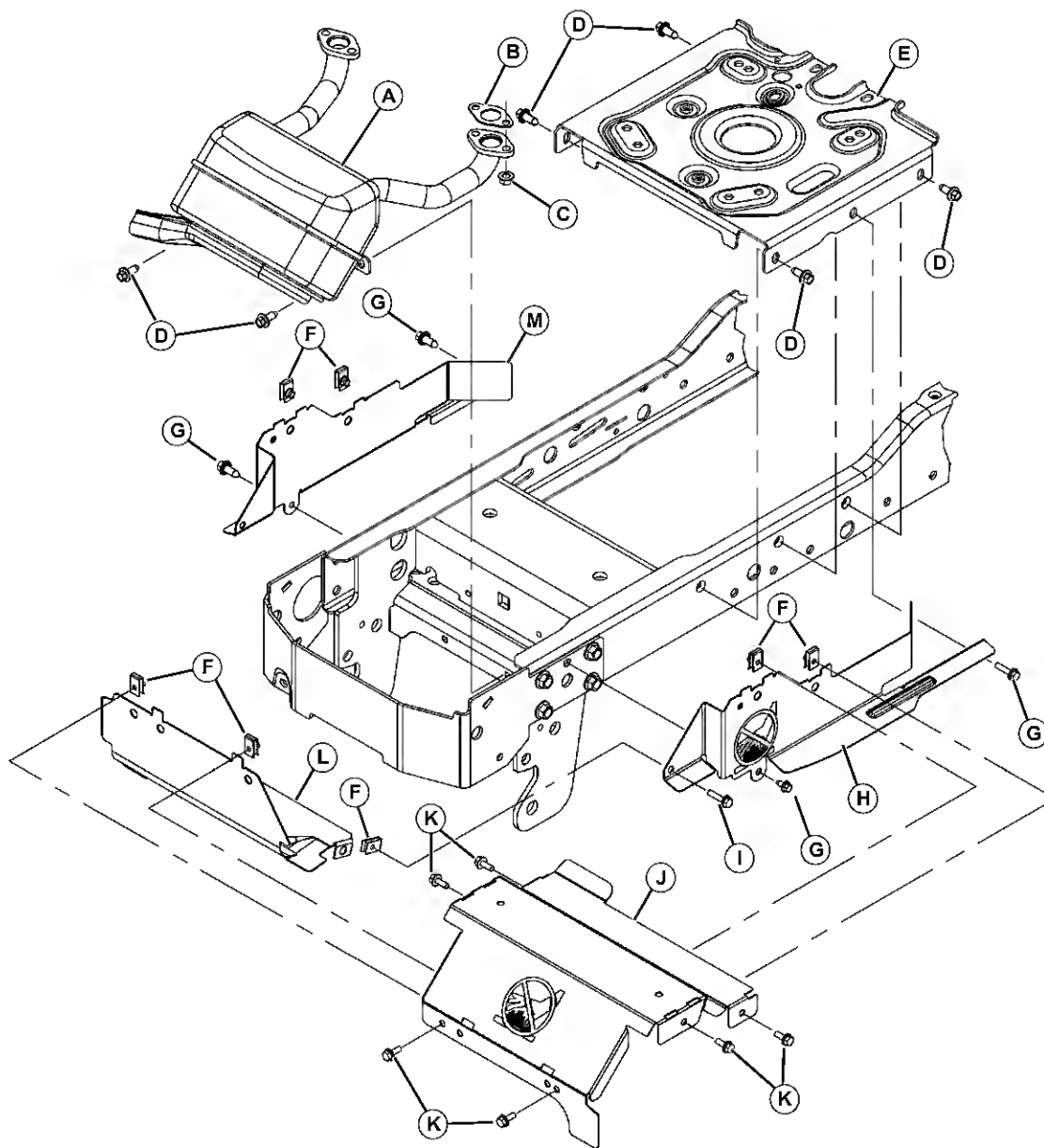
## ENGINE - KAWASAKI (FH491V) COMPONENT LOCATION

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E- Stud  
F- Spring Retainer  
G- Valve Spring  
H- Intake Valve  
I- Exhaust Valve  
J- Spring  
K- Cam Shaft  
L- Plate  
M- Guide  
N- Snap Ring  
O- Ball  
P- Concave Plate  
Q- Sleeve  
R- Washer  
S- Screw  
T- Retainer  
U- Sump  
V- Seal  
W- Governor Link  
X- Governor Spring  
Y- Screw  
Z- Governor Shaft  
AA- Governor Arm  
AB- Washer  
AC- Nut  
AD- Spring  
AE- Cable Retainer  
AF- Screw  
AG- Screw  
AH- Spring  
AI- Screw  
AJ- Plate  
AK- Screw  
AL- Pushrod Guide  
AM- Pushrod  
AN- Tappets

# ENGINE - KAWASAKI (FH491V) COMPONENT LOCATION

## Engine Shields



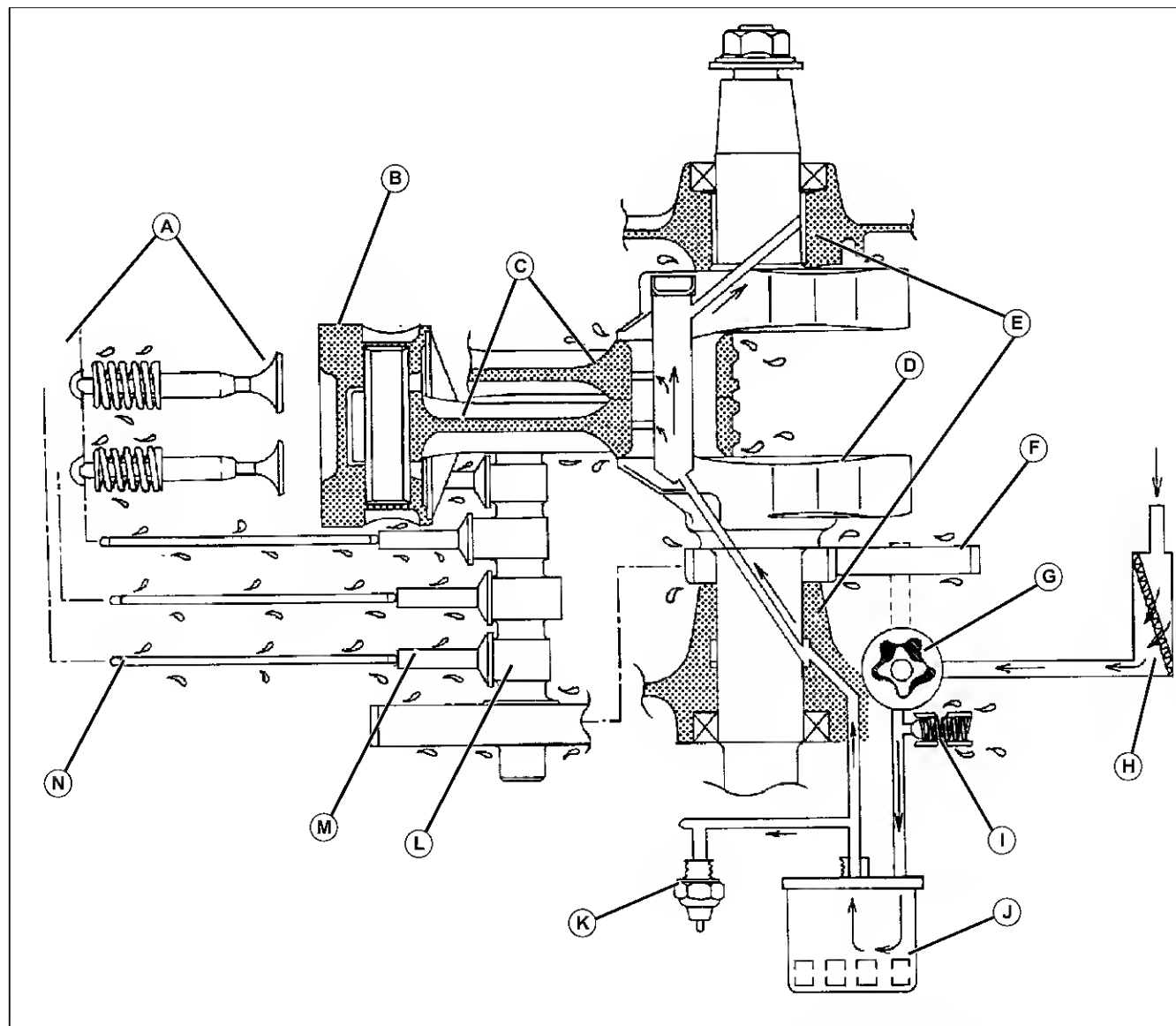
- A- Muffler
- B- Gasket (2 used)
- C- Flange Nut M8 (4 used)
- D- Screw (6 used)
- E- Engine Base Plate
- F- Clip Nut (8 used)
- G- Screw M6x25
- H- Shield LH
- I- Screw M6x12
- J- Shield, Upper
- K- Screw M6x16 (6 used)

L- Shield, Lower  
M- Shield RH

# ENGINE - KAWASAKI (FH491V) THEORY OF OPERATION

## Theory of Operation

## Engine Oil Flow Chart



M99565

### Lubrication System Operation

- A- Rocker Arms and Valves
- B- Piston
- C- Connecting Rods
- D- Crankshaft
- E- Crankshaft Main Bearings
- F- Oil Pump Gear
- G- Oil Pump
- H- Pick-up Screen
- I- Oil Pressure Relief Valve
- J- Oil Filter
- K- Oil Pressure Sensor
- L- Camshaft
- M- Tappets
- N- Push Rods

#### Function:

To provide pressurized oil to lubricate internal engine components.

#### Theory of Operation:

A positive displacement gerotor pump is used to pressurize the lubrication system. The lubrication system is protected by an oil pressure relief valve, low oil pressure switch, and an oil filter with bypass valve.

The oil pump draws oil from the sump through the pick-up screen. Pressure oil from the pump flows through the pump outlet passage past the oil pressure relief valve. The oil pressure relief valve limits the oil pressure to approximately **296 kPa (43 psi)** and protects the oil pump from damage if

# ENGINE - KAWASAKI (FH491V) THEORY OF OPERATION

an oil passage becomes blocked. If the oil pressure exceeds 296 kPa (43 psi), the relief valve opens allowing oil to return to the sump. The relief valve is not adjustable.

Pressure oil flows past the relief valve to the oil filter. The filter contains a bypass valve which opens at **78.5 - 117.5 kPa (11.4 - 17.1 psi)** if the element becomes plugged to ensure engine lubrication.

An oil pressure switch mounted above the oil filter turns on a warning light if oil pressure is below **98 kPa (14.2 psi)**. Filtered pressure oil flows through a passage in the oil sump to the crankshaft main bearing (PTO side). Drilled passages in the crankshaft distribute oil from the main bearings to the connecting rod journals and crankshaft main bearings (flywheel side). A drilled passage in the connecting rods allows oil from the connecting rod journal to lubricate the piston and cylinder walls.

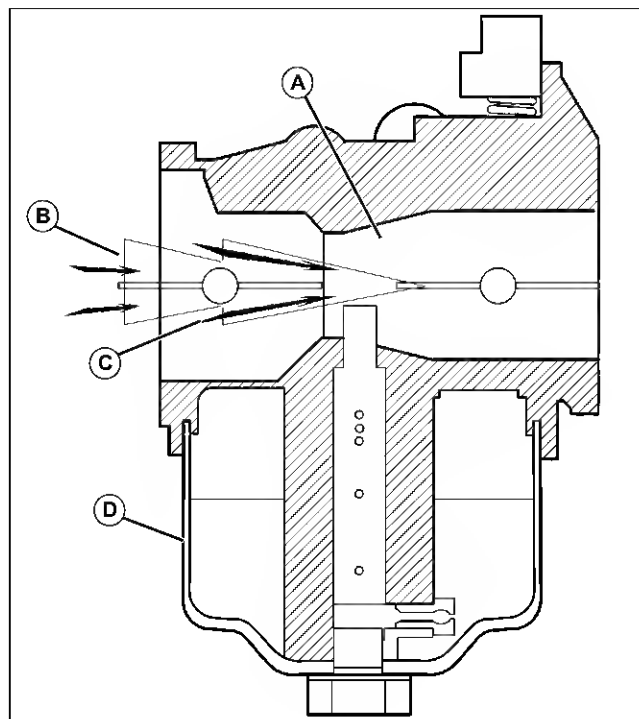
In the cylinder head, the rocker arms, valves, and pushrods are lubricated by an oil/air mixture carried through an upper lubrication passage from the breather chamber. As this oil/air mixture is swirled around the rocker arm chamber, the oil particles cling to the moving parts, lubricating them. Eventually these oil particles collect into a liquid state again in the lower portion of the rocker arm chamber. A small return passage is provided to return this liquid state oil back into the crankcase.

The breather creates a negative pressure in the crankcase which prevents oil from being forced out of the engine through the piston rings, oil seals or gaskets. Cylinder blow-by gases go through the crankcase to the breather chamber. They are drawn into the engine side of the air cleaner through the cylinder head and mixed with the clean air flow as part of the emission control system.

The camshaft gear, camshaft, tappets, coolant pump gear, governor gear, oil pump gear, and crankshaft gear are lubricated by oil splash generated by the internal moving parts during operation.

## Carburetor Operation

### Function



MX47326

- A- Venturi
- B- Carburetor Throat
- C- Increased Air Speed
- D- Fuel Bowl

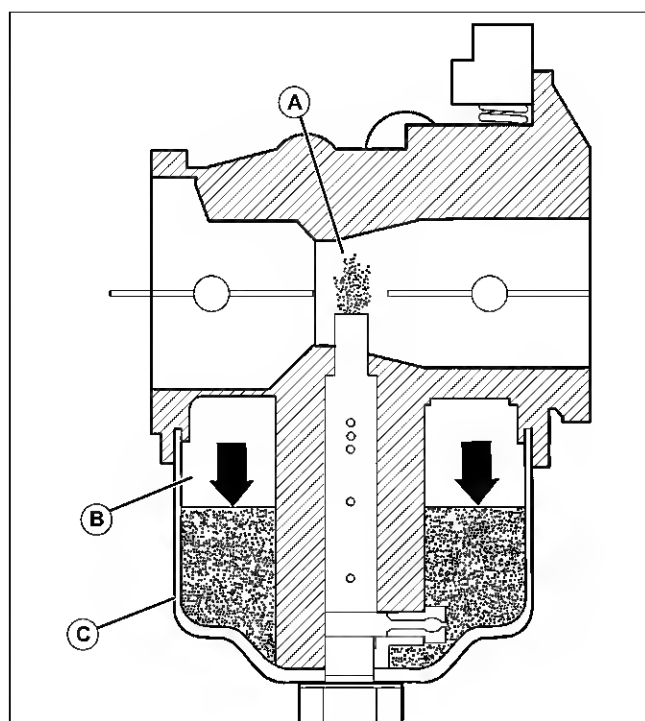
The function of the carburetor is to create fuel flow, atomize the fuel, and meter the air/fuel mixture so it can be combusted in the engine. To create fuel flow through the carburetor, there must be a pressure differential between the fuel bowl and the throat of the carburetor.

### Venturi

Air goes through the carburetor throat. When it reaches the venturi, the air speed is increased and the air pressure is decreased. The venturi is a restriction in the carburetor located between the choke and throttle valves. The restriction causes air to speed up resulting in a lower than atmospheric pressure area in the carburetor throat.



# ENGINE - KAWASAKI (FH491V) THEORY OF OPERATION



MX47327

- A- Venturi Low Pressure
- B- High Pressure
- C- Fuel Bowl

A vent passage in the carburetor maintains pressure from the atmosphere on the fuel in the fuel bowl. Since fluids flow from areas of higher pressure to areas of lower pressure the resulting pressure differential between the fuel bowl (high pressure) and the venturi (low pressure), causes fuel to be pushed (flow) from the fuel bowl to the venturi.

There are two types of bowl venting: external and internal.

**Note: Late model carburetors are internally vented to meet emissions standards.**

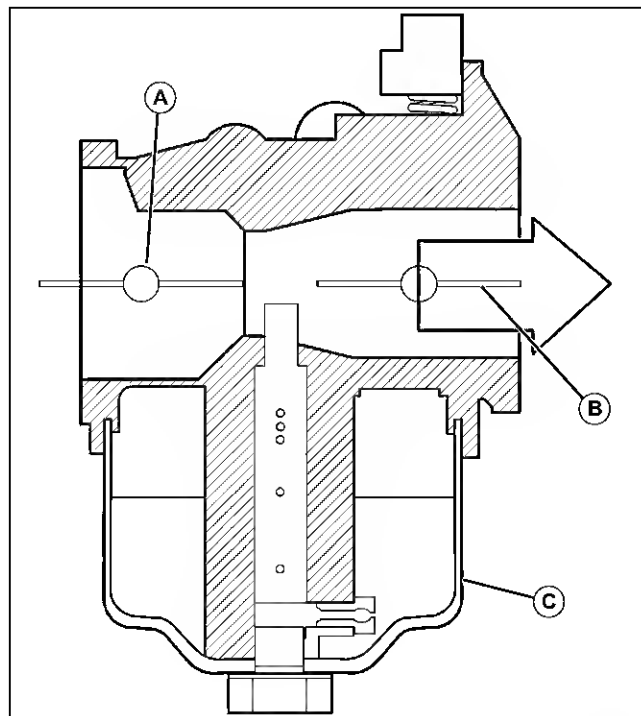
Externally vented carburetors exert direct atmospheric pressure from outside of the air filter onto the fuel in the bowl.

Internally vented carburetors exert indirect atmospheric pressure from inside the air filter, ahead of the choke valve, onto the fuel in the bowl.

## Fuel Bowl and Float

The fuel bowl is the fuel reservoir for the carburetor. In order to maintain the proper fuel air/mixture, the fuel level must be constant. The float maintains the level of fuel in the bowl while regulating the fuel flow to match the demands of the engine by controlling the inlet float valve (needle).

## Control Valves



MX47328

- A- Choke Valve
- B- Throttle Valve
- C- Fuel Bowl

The carburetor has two control valves: throttle valve and choke valve.

The throttle valve is operated by the throttle lever and controlled by the governor. The throttle valve controls how much air and fuel enters the cylinder(s).

The choke valve, located before the venturi, creates a restriction when closed. The function of the choke valve is to increase the pressure differential between the fuel bowl and the venturi area. This results in increased fuel flow from the bowl to the venturi, enriching the air/fuel mixture.

In some engines, a primer is used in place of a choke valve to push fuel into the venturi.

## Concept of Idle

Governed engines are designed to maintain a specific engine speed.

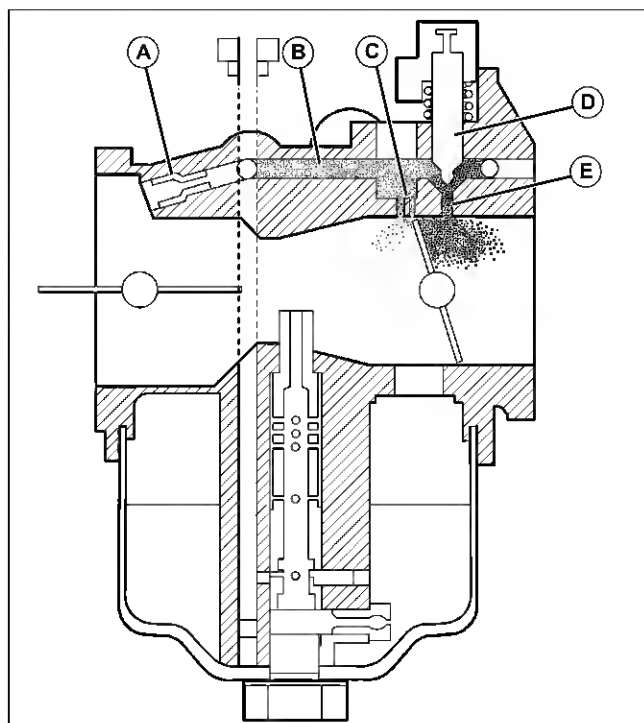
Governed engines with no load (PTO disengaged, drive in neutral) are said to be at "idle" regardless of engine speed. When the operator selects the low speed position with no load, the engine is at low idle. When the operator selects the high speed position with no load, the engine is at high idle.

Carbureted engines account for these situations with two circuits; an idle circuit (no load) and a main circuit (under

# ENGINE - KAWASAKI (FH491V) THEORY OF OPERATION

load).

## Idle Circuit



MX47329

- A- Air Bleed
- B- Idle Circuit
- C- Transitional Bypass Openings
- D- Pilot Valve
- E- Pilot Opening

The idle circuit, on a governed engine, delivers air and fuel primarily when the engine is not under load (PTO disengaged, drives in neutral).

Fuel flow enters the idle circuit from the main jet but is metered by the idle jet. The fuel is then emulsified with air passing through an air bleed and combining with the fuel. The air/fuel mixture travels to the transitional bypass openings and the pilot opening.

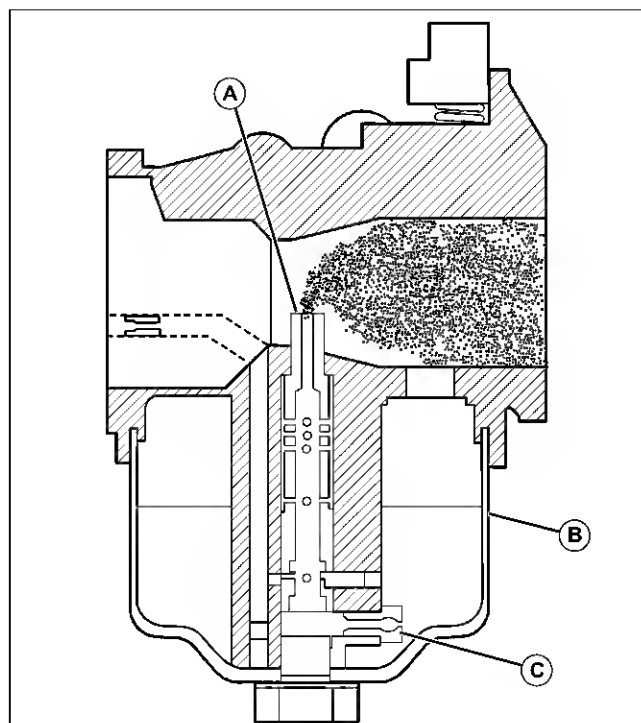
When the throttle valve is closed, the engine receives its air/fuel mixture through the pilot opening. The pilot opening is used for low idle operation. The pilot opening is located between the closed throttle plate and the intake manifold. The opening has a pilot screw that allows for some adjustment. This adjustment primarily affects low idle.

When the governor slightly opens the throttle valve for high idle or when a load is applied, the transitional bypass openings are exposed. These additional openings increase air/fuel flow to the engine.

Once the engine is under a heavier load, the throttle valve is opened beyond the transitional bypass openings. At this point the carburetor receives fuel primarily from the main

circuit.

## Main Circuit



MX47330

- A- Emulsion Tube
- B- Fuel Bowl
- C- Main Jet

The main circuit, on a governed engine, is used only when the engine is under load. Fuel flows from the fuel bowl through the fixed main jet into the main circuit.

Air enters through a metered orifice (air-bleed) and emulsifies (mixes) air and fuel as it travels up the emulsion tube to the venturi.

Emulsification is an important process to properly atomize the fuel and promote efficient combustion.

## Fuel Shutoff Solenoid

The fuel shut-off solenoid reduces fuel flow to the main circuit. The function of the fuel shut-off solenoid is to minimize after-bang.

At engine start up, the fuel shut-off solenoid is energized and the poppet retracts from the seat in the bowl, allowing fuel to enter into the main jets.

To bench test the fuel shut-off solenoid, apply light pressure to the tip to simulate its mounting in the fuel bowl and apply 12 volts DC. If the needle retracts, the solenoid is working. Verify the tip is secured to the plunger.

# ENGINE - KAWASAKI (FH491V) DIAGNOSTICS

## Diagnostics

### Engine Troubleshooting Guide



**Caution: Avoid Injury! The engine may start to rotate at any time. Keep hands away from moving parts when testing.**

**Note: To test specific electrical components, see Electrical Section and refer to either Diagnostics or Tests & Adjustments for further guidance.**

#### Test Conditions:

- Operator on seat.
- PTO switch in off position.
- Brake on.

### Engine Diagnostics

#### Engine Doesn't Crank

1. Are battery cables loose or dirty?

Yes: Tighten or clean.

No: Go to next step

2. Is battery fully charged? See "Battery Test" on page 343 in the Electrical section.

Yes: Go to next step

No: Charge Battery. See "Charge Battery" on page 344 in the Electrical Section.

3. Is key switch working correctly?

Yes: Go to next step.

No: Test Switch, Replace as needed.

4. Is starter motor defective? See "Starting Motor Troubleshooting Guide" on page 37.

Yes: Repair or replace.

No: Go to next step.

5. Is alternator defective?

Yes: Repair or replace.

No: Go to next step.

6. Has engine seized?

Yes: See engine Repair Section.

No: Go to next step

7. Is starting motor or solenoid defective?

Yes: Repair or replace. See "Starting Solenoid Test" on page 349.

No: Go to next step.

8. Is there a open circuit in wiring?

Yes: Repair or replace.

No: Go to next step.

9. Is the fuel shutoff solenoid operating correctly?

Yes: Go to next step.

No: Repair or replace.

10. Is the fuel filter or fuel lines clogged?

Yes: Clean or replace as necessary.

No: Go to next step.

11. Is the fuel pump operating correctly? See "Fuel Pump Test" on page 51.

Yes: Go to next step.

No: Clean or replace as necessary.

12. Is their water in the fuel?

Yes: Drain and replace fuel.

No: Go to next step.

13. Are the valves adjusted properly?

Yes: Go to next step.

No: Adjust valve clearance. See "Valve Clearance, Check and Adjustment" on page 47.

14. Does engine have correct compression? See "Cylinder Compression Pressure Test" on page 49.

Yes: Go to next step.

No: Check for seized or burned valves, broken piston rings, or worn cylinder

15. Is air sucked through carburetor or intake manifold flanges?

Yes: Tighten manifold flange nuts or replace damaged gasket.

No: Go to next step

#### Engine Hard To Start

1. Are battery cables loose or dirty?

Yes: Repair.

No: Go to next step.

2. Is there a strong blue spark? See "Spark Test" on page 51.

Yes: Go to next step.

No: Repair or replace ignition module.

3. Are sparks jumping from produced between high tension lead and ignition block. Check high tension lead, ignition coil air gap, pulser coil.

# ENGINE - KAWASAKI (FH491V) DIAGNOSTICS

Yes: Repair or Replace parts as needed

No: Go to next step

4. Is engine compression good? See "Cylinder Compression Pressure Test" on page 49.

Yes: Go to next step.

No: Check piston rings and cylinder for wear. See "Piston Inspection:" on page 67. Inspect Cylinder head. See "Cylinder Head Inspection" on page 61.



**Caution: Avoid Injury! Keep spark plug as far away from the plug hole as possible. Gasoline spray from the open cylinders may be ignited by ignition spark and cause an explosion or fire.**

5. Make starting attempts a number of times, remove spark plug and observe electrodes. After starting attempts, are spark plug electrodes wet?

Yes: Check for excessive use of choke, plugged air cleaner, float bowl level too high.

No: Go to next step

## Engine Runs Erratically

1. Is fuel delivery correct? See "Fuel Pump Test" on page 51.

Yes: Go to next step.

No: Check for defective fuel pump or plugged fuel lines or fuel tank.

2. Is fuel present in carburetor?

Yes: Go to next step.

No: Check for plugged air/fuel passages in carburetor. See "Carburetor Removal, Disassembly, and Installation" on page 55.

3. Is there contamination in fuel lines, or fuel tank?

Yes: Repair or replace parts as needed

No: Go to next step

## Engine Malfunctions At Low Speed

1. Is unusual smoke emitted out of muffler?

Yes: Check choke. See "Choke Cable Adjustment" on page 44.

No: Go to next step.

2. Does engine rpm drop or engine stall at a certain point when throttle is gradually opened by hand?

Yes: Check for obstruction or plugged passage in carburetor. See "Carburetor Removal, Disassembly, and Installation" on page 55.

No: Go to next step.

3. Is air sucked through carburetor or intake manifold flanges?

Yes: Tighten manifold flange nuts or replace damaged gasket.

No: Go to next step

4. Are valve clearances set correctly? See "Valve Clearance, Check and Adjustment" on page 47.

Yes: Go to next step.

No: Adjust valves.

## Oil Consumption Is Excessive

1. Check for oil leaks, high oil level, clogged breather valve, plugged drain back hole in breather, Is oil viscosity correct?

Yes: Repair as required.

No: Go to next step.

2. Is compression correct? See "Cylinder Compression Pressure Test" on page 49.

Yes: Go to next step.

No: Check for worn, stuck, or broken piston rings, or worn cylinder bore.

## Low Oil Pressure

1. Is oil level correct?

Yes: Go to next step.

No: top off oil to correct level.

2. Is oil filter clogged?

Yes: Replace Oil Filter.

No: Go to next step.

3. Is oil of correct viscosity?

Yes: Go to next step.

No: Change engine oil.

4. Check for oil leaks, high oil level, clogged breather valve, plugged drain back hole in breather, Is oil viscosity correct?

Yes: Repair as required.

No: Go to next step.

5. Is oil relief valve worn?

Yes: Clean, adjust or replace relief valve.

No: Go to next step.

6. Is oil pump operating correctly? See "Engine Oil Pressure Test" on page 50.

Yes: Go to next step.

No: Replace oil pump.

7. Is there fuel in the oil?

# ENGINE - KAWASAKI (FH491V) DIAGNOSTICS

Yes: Check for broken or seized piston Rings or worn cylinder.

No: Go to next step.

8. Is oil pump screen clogged or pick up tube cracked?

Yes: Clean screen and repair or replace pick up tube.

No: Go to next step.

9. Is there excessive crankshaft or rod bearing clearance?

Yes: Regrind crankshaft and install undersize connecting rods.

No: Go to next step.

10. Intake/exhaust valves or guides worn?

Yes: Replace valves and head.

No: Go to next step.

## Contamination in Crankcase

1. Is there fuel in the crankcase?

Yes: Check for broken or seized piston rings or worn cylinder. Check for worn or seized exhaust valve.

No: Go to next step.

2. Is there water in the crankcase?

Yes: Check to make sure that crankcase breather is working correctly. See "Crankcase Vacuum Test" on page 49. See "Breather Inspection" on page 59.

No: Go to next step

## Starting Motor Troubleshooting Guide



**Caution: Avoid Injury! The engine may start to rotate at any time. Keep hands away from moving parts when testing.**

**Important: Avoid Damage! If starting motor does not stop rotating by turning ignition switch to Off position, disconnect negative (-) lead from battery as soon as possible.**

**Note: To test specific electrical components, see Electrical Section and refer to either Diagnostics or Tests & Adjustments for further guidance.**

### Starting Motor Diagnostics

#### Starter Does Not Rotate

1. Is there a click sound from the starter solenoid?

Yes: Go to next step.

No: Repair starter motor. See "Starting Motor" on page 76.

2. Check that all starting conditions are met?

Yes: Go to next step.

No: Make sure all starting conditions are met.

3. Are battery cables loose or dirty?

Yes: Clean and tighten.

No: Go to next step.

4. Is battery fully charged? See "Battery Test" on page 343 in the Electrical Section.

Yes: Go to next step.

No: Charge battery. See "Charge Battery" on page 344.

5. Is key switch working correctly?

Yes: Go to next step.

No: Repair or replace key switch

6. Is engine seized?

Yes: See Engine Repair section.

No: Go to next step

#### Starter Rotates Slowly

1. Are battery cables loose or dirty?

Yes: Clean and Tighten.

No: Go to next step.

2. Is battery fully charged?

Yes: Go to next step.

No: Charge battery. See "Charge Battery" on page 344.

3. Is there a click sound from the starter solenoid?

Yes: Go to next step.

No: Repair starter motor. See "Starting Motor" on page 76.

4. Is engine seized?

Yes: See Engine Repair section.

No: Go to next step

5. Is starting motor or solenoid defective?

Yes: Repair or replace. See "Starting Solenoid Test" on page 349.

No: Go to next step.

## Carburetor Troubleshooting Guide

### Engine Will Not Start

1. Is there fuel?

# ENGINE - KAWASAKI (FH491V) DIAGNOSTICS

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Yes: Go to next step.

No: Add fuel, check fuel lines.

2. Is fuel line plugged?

Yes: Clean fuel line and fuel filter. Check for fuel supply at carburetor.

No: Go to next step.

3. Does the fuel solenoid open?

Yes: Go to next step.

No: Test solenoid and power to solenoid. See Electrical section.

4. Is the main jet clogged?

Yes: Disassemble and clean jet and passages.

No: Go to next step.

5. Is the needle valve stuck closed?

Yes: Check for old or gummy fuel. Clean carburetor. Check valve tip.

No: Go to next step.

## Engine Cranks But Is Hard to Start

1. Is the air filter clean?

Yes: Go to next step.

No: Clean or replace air filter.

2. Is the choke plate opening properly?

Yes: Go to next step.

No: Adjust choke cable. See choke cable and throttle cable adjustment.

3. Check passages in carburetor. Are passages open and free of debris or varnish?

No: Clean carburetor.

## Engine Idles But Does Not Run Under Load

1. Check main jet. Is main jet dirty?

Yes: Clean carburetor.

No: Go to next step.

2. Check main jet for proper size. Is correct main jet used?

No: Replace main jet.

## Engine Idles, Runs (loaded or not) Then Stops

1. Is the fuel system properly vented?

Yes: Go to next step.

No: Check fuel cap if vented cap is used. Check vent lines to carburetor for kinks, or collapsed or weak areas.

2. Is dirt in the bowl being sucked into main jet?

Yes: Check float bowl for dirt or corrosion, clean bowl. Check main jet for loose debris.

## Engine Does Not Idle Properly (hunts or surges)

1. Check to see if the problem is governor or carburetor: Hold the throttle plate closed to force engine to idle. Does the engine continues to run? check governor. If the engine stalls - suspect idle circuit.

Yes: Check governor for proper operation.

No: If engine stalls, check idle circuit. Clean carburetor with attention to idle circuit passages.

## Engine Idles, Does Not Run Properly At Wide Open Throttle (WOT)

1. Check float bowl for dirt or corrosion. Check for dirt between needle valve and seat. Is dirt or debris present?

Yes: Clean bowl and valve seat.

No: Go to next step.

2. Is float sticking or not set properly?

Yes: Clean float pivot. Adjust float.

No: Go to next step.

3. Check air passage and pilot jet for debris or varnish. Is there debris in the idle air bleed or pilot jet?

Yes: Clean carburetor.

## Carburetor Air/Fuel Diagnosis

Defects in carburetors would be apparent very early in the life of the engine. The majority of fuel system problems are related to stale or improper fuel or dirt. This section is to help you diagnose fuel system problems.

### Initial Checklist

- How old is the fuel?
- Does the fuel have a foul smell?
- Is the fuel cloudy, dark or dirty?
- Is the fuel tank cap air vent clean and open?
- Is a clean, correct air filter installed?
- Has the ignition system been verified?
- Is the air filter and carburetor attached properly?
- Is the intake manifold loose and/or leaking?
- Is the fuel shut-off solenoid operating properly?
- Is the governor throttle linkage moving properly?
- Is the float operating properly?
- If the carburetor is externally vented, is the vent line unrestricted?

# ENGINE - KAWASAKI (FH491V) DIAGNOSTICS

**Note:** Other engine failures such as plugged exhaust or improper valve clearance can cause symptoms similar to faulty fuel supply. Verify the quality of the engines mechanical and electrical systems.

## Engine Surge

An engine that surges may have an improper air/fuel mixture or a misadjusted or worn governor.

Attempt to manually control the throttle at low and high idle to determine which system is causing the surge. If the engine speed can be held constant check the governor system. If the engine surge cannot be controlled manually, check the fuel system.

Fuel system issues may consist of:

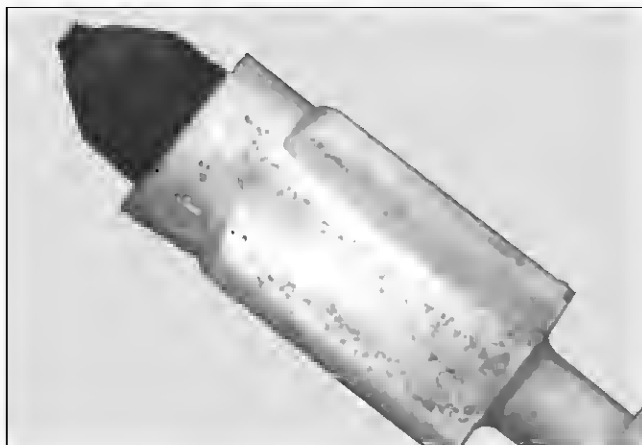
- Improper air/fuel mixture caused by air leaks around the throttle shaft, intake and/or insulator gaskets.
- Minor restrictions inside the carburetor passages from varnish and debris buildup in the idle circuit. Properly cleaning the carburetor will likely fix the problem.

## Rich Air/Fuel Mixture

There are several possible causes of a rich running condition such as: improper or stale fuel, short-tripping, air filter, choke adjustment and/or vent tube location.

**Note:** Verify the ignition system. A rich running condition can have the same symptoms as an improperly operating ignition system.

## Float Valve



MX47331

### Float Valve with Worn Tip Shown

Fuel level in the float bowl is regulated by the float and the float valve. A worn float valve tip provides too much fuel and will cause a rich condition.

## Improper or Stale Fuel

Poor fuel quality can cause an engine to appear to be running rich. Improper or stale fuel can cause engine

components to stick or deteriorate.

## Short-Tripping

A common misdiagnosis comes from short-tripping machines (engines that are started for short periods of time). Short-tripping causes the engine to develop black, sooty spark plugs and contamination in the oil. Over time, short-tripping can lead to glazed cylinder walls. To prevent this, every time the engine is started, allow the engine to reach operating temperature and load the machine.

## Air Filters

**Note:** Late model carburetors are internally vented to meet emissions standards.

Engines with externally vented carburetors with a dirty air filter will exhibit rich running conditions. When a dirty air filter restricts air flow to the carburetor, the low pressure in the venturi drops even further, resulting in a higher pressure differential between the fuel bowl and the venturi. Therefore, a dirty air filter can enrich the air/fuel mixture to the point that performance will drop.

Engines with internally vented carburetors will not exhibit rich running conditions with a dirty air filter. When a dirty air filter restricts air flow to the throat of the carburetor, an equal reduction will be applied to the bowl vent. Internally vented carburetors maintain the pressure differential between the bowl and the venturi resulting in a consistent air/fuel mixture over the life of the air filter.

## Vent Tube Location

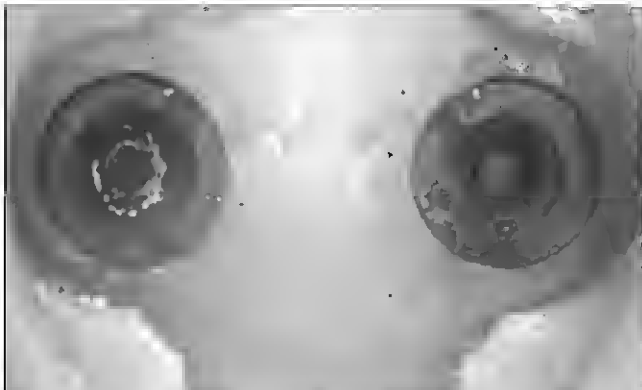
With an externally vented carburetor, a rich or lean run condition could also be caused by the location of the float bowl vent tube. The purpose of the vent tube is to allow atmospheric pressure into and out of the float bowl. Air from the cooling fan at the vent tube opening can cause a pressure increase or decrease on the fuel in the float bowl and cause the engine to run rich or lean. Check for bulletins and relocate the float bowl vent tube to a location away from any source of turbulence.

# ENGINE - KAWASAKI (FH491V) DIAGNOSTICS

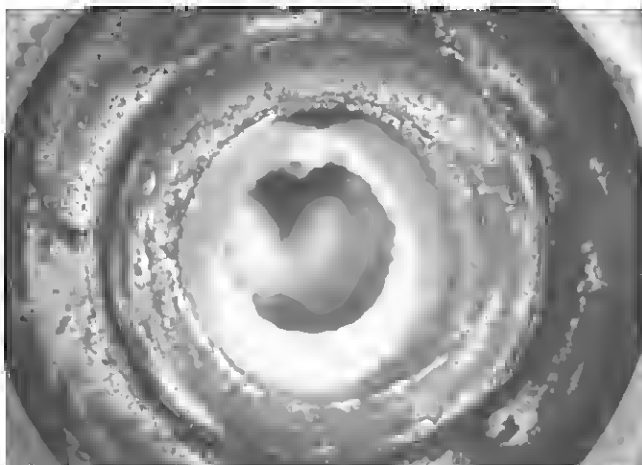
## Carburetor Diagnostic Inspection

Inspect the carburetor float bowl and passages for debris, varnish buildup, and corrosion.

Check for damaged parts or parts installed incorrectly.



MX47332 and MX47333



MX47469

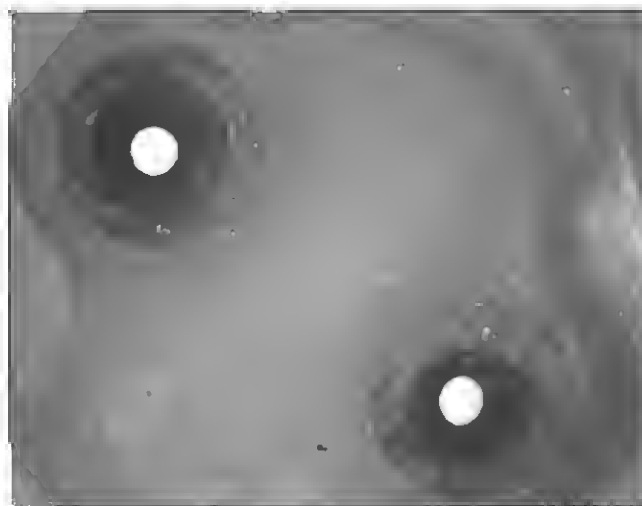
1. White corrosion or green corrosion is usually caused by water. Water can combine with other chemicals and create acids and salts which accelerate corrosion. Water can be absorbed by ethanol, so the more ethanol, the worse the problem.

Extreme corrosion may involve salt water. Sometimes the exterior of the carburetor will also be corroded. The location of the machine (such as coastal regions) will provide additional clues to the cause of corrosion.



MX47472

2. Red or brown corrosion is usually caused by an iron or steel part that has corroded. Look at steel fuel inlet fittings, steel parts in fuel filters. It could also indicate some other contaminant in the fuel. Some microbial contaminations can be reddish.



MX47471

3. Brown varnish and gum deposits are generally from old degraded fuel. It usually has a distinctive "old varnish" smell. Look for it in areas that would be adversely affected, such as fuel and air passages, needles and seats.

4. Damage from excessive ethanol, methanol, MTBE, ethers, will usually be seen as damage to rubber parts. Look for cracks, swelling, shrinking, loss of elasticity, takes a permanent set or becomes hard or brittle. Look for plastic damaged parts.

5. Debris stuck in small orifices and other critical areas. Look in jets, fuel and air passages, fuel inlet needle and seat, idle mixture adjustment needles and seats, idle progression holes, fuel shutoff solenoid plunger, etc. The



# ENGINE - KAWASAKI (FH491V) GENERAL INFORMATION

material of the debris can help determine the source. Look for the following:

- a. Cellulose and other organic fibers are usually grass debris that was ingested by the engine air intake or fuel system, they could also be fibers from the fuel filter element.
  - b. Sand can come from ingesting dirt by the engine air intake system or fuel system or from unclean manufacturing and parts packaging.
  - c. Metallic particles such as aluminum, brass, and iron chips typically come from the manufacturing process and unclean parts packaging and assembly areas.
  - d. Plastic particles usually come from manufacturing processes such as plastic molding, welding, adhesive (epoxy used in fuel filters), and unclean part packaging and assembly areas.
  - e. Rubber particles usually come from the fuel lines, fuel pump diaphragms, or internal parts, and unclean part packaging and assembly areas.
  - f. Cardboard particles and fibers usually come from parts packaging and unclean assembly areas.
  - g. Hair fibers usually come from unclean parts packaging and assembly areas.
6. Wrong parts, such as wrong size jet or left and right jets switched.
7. Damaged parts, such as jets having tool marks that affect the fuel flow, cracked plastic parts, etc.
8. Defective parts such as porosity in castings, excessive flash on castings or molded parts, defective welds or adhesive joints, throttle shafts that fit too tight or too loose, throttle plates out of alignment or not matched to bores, etc. Defective machining is difficult to diagnose unless it's obvious.

## General Information

### Cleaning Carburetors

Debris, corrosion, rust, or varnish can build up in the internal air/fuel passages. Many times the contamination is located in an area of the carburetor that is not visible. In most cases proper cleaning can resolve these issues.

Carburetors and carburetor components can be cleaned by using one of several types of commercial cleaning methods: aerosol sprays, caustic dip tanks, and ultrasonic cleaners.

**Note: Some cleaning chemicals may be flammable and have toxic fumes. Always follow the chemical manufacturer's recommendations. Always wear personal protection gear such as safety glasses**

**protective gloves and work in a well ventilated area. Do not use drill or hard wire to clean carburetor passage ways.**

### Cleaning Procedure

Always follow the solvent manufacturer's recommendations for material compatibility because some solvents may attack metal, plastic or rubber components.

1. Clean debris off the outside of the carburetor before disassembly.
2. Completely disassemble the carburetor per the instructions in the Technical Manual and visually inspect.
3. Determine if carburetor is repairable, excessive corrosion may determine this is not practical.
4. If repairable, clean any remaining dirt and old gaskets from the carburetor.

The preferred method of cleaning is to use an ultrasonic cleaner.

**Important: Avoid Damage!** Wires and metal instruments should not be used. Light damage or deposits on the surface of the float valve seat can be removed using a cotton swab with a mild abrasive such as toothpaste or 800 grit lapping compound.

### Carburetor Assembly

When the carburetor is ready for assembly, lay out all the necessary components on a clean surface. Be aware that even clean shop rags may contain dirt and metal shavings. Assemble the carburetor in accordance with the instructions in the Technical Manual. Keep the following in mind:

- Check the throttle shaft for excessive play or movement and any signs of binding.
- Never use oil on the throttle shaft because it attracts dirt which can cause premature wear of the throttle shaft seals.
- If the throttle shaft was removed use new screws and follow the service manual torque specifications.
- Always check the float and float valve for binding with the float valve installed in its proper position.
- Replacement of all gaskets and seals is necessary when servicing any carburetor.
- Inspect the carburetor insulator for damage and replace if necessary. Be sure to install the insulator using the correct orientation.
- Clean and flush the complete fuel system.
- Fuel lines must be replaced if they are brittle, cracked, excessively soft or damaged.
- Replace the fuel filter and air filter after cleaning the

# ENGINE - KAWASAKI (FH491V) GENERAL INFORMATION

carburetor.

## Cleaning Methods

### Ultrasonic Cleaning Systems

Ultrasonic cleaners use environmentally friendly cleaning solution and sound waves to penetrate deep into carburetor passages. Heating the solution is an option on ultrasonic cleaners that significantly increases the effectiveness of the system. Ultrasonic cleaner systems work by creating sound wave pulses that are transmitted through a cleaning solution. Manufacturers of ultrasonic cleaners claim the pulses create small bubbles that loosen and pulverizes contaminants. Select a chemical solution that is designed specifically for carburetor cleaning.

Generally, chemicals will need to be diluted with water prior to use. When choosing a chemical, consider dilution rates to help determine which chemical is the most cost effective. Consider disposal of cleaning solution before ordering chemicals. Check with local authorities on recommended disposal methods before disposing of any cleaning solution. Ultrasonic cleaners come in many sizes. Most 1.5-2 gallon tanks will be sufficient for carburetors used by John Deere gas engines.

If an Ultrasonic Cleaner is used, place carburetor in and run for 30 minutes at 110 F in the proper solution mix. If the solution is too strong or the carburetor is left in the cleaner for too long, the aluminum body will have a residue on the surface from the aluminum oxidizing.



**Caution: Avoid Injury! Compressed air can cause debris to fly a long distance.**

- Clear work area of bystanders.
- Wear eye protection when using compressed air for cleaning purposes.
- Reduce compressed air pressure to 210 kPa (30 psi).

Rinse the parts in water and dry with compressed air (up to 30 psi).

Wash off and blow ports out in carburetor body/ fuel transfer tubes / and discharge port. Blow compressed air through carburetor passages in the opposite direction of the air/fuel flow (into the smallest passages to flush debris out of the larger passages). This will prevent debris lodging in difficult to clean areas.

### Aerosol Cleaner

Personal safety, environmental concerns and cleaning effectiveness make this method the least desirable. This method can be used on carburetor components that may be damaged by caustic cleaners (rubber seals or other

non-metallic components). When cleaning with aerosol sprays, it is always best to spray in the opposite direction of the air/fuel circuit (into the smallest passages to flush debris out of the larger passages). This will prevent debris lodging in difficult to clean areas.



**Caution: Avoid Injury! Vapors from solvents can be explosive and flammable. Follow the instructions on the container label for safe use of the solvent:**

- Work in a well-ventilated area.
- Wear protective clothing when handling solvent.
- Do not smoke while handling solvents.
- Keep solvent away from flames or sparks.

### Caustic Dip Tanks

Caustic dip tanks use aggressive chemicals to dissolve carbon based contamination. This method is effective for most carburetor cleaning needs.

Rotating the parts in the tank will ensure the cleaning solution flushes out any air pockets left in the passages. Follow the recommendation on the cleaner for submersion times. Disadvantages of the caustic dip tanks are that some carburetor parts may be damaged if left in solution too long.

Personal safety and chemical disposal are additional concerns. Because the chemical is caustic, exposure may cause injury or death. Disposal of used solution can be difficult because most cleaners are considered hazardous waste.

### Fuel

Use only fuels recommended in Operator's Manual:

Use regular grade unleaded fuel with an octane rating of 87 octane or higher. Fuel blends containing up to 10% ethanol or up to 15% MTBE reformulated fuel are acceptable. DO NOT use fuels with more than 10% ethanol (i.e. E85 should not be used because it is 85% ethanol and 15% gasoline) or fuels with more than 15% MTBE reformulated fuel as these products will damage engine and or fuel system. Do not use fuel or additives containing methanol as engine damage can occur.

All fuel today is formulated for the automotive industry. Fuel is "blended" differently for winter and summer use; regardless of where you are. "Winter" fuel is blended for improved vaporization in colder temperatures. Using left over "Winter" fuel in warmer Spring/Summer temperatures will likely cause vapor locking and surging. Newer carburetors on current production machines have less

# ENGINE - KAWASAKI (FH491V) TESTS AND ADJUSTMENTS

tolerance for poor quality fuel because of the tighter specifications required to meet EPA certification.

## Fuel Storage

Since it is difficult to know what type of fuel is in different areas; it is best to handle and maintain fuel as outlined below:

1. Deteriorated/stale fuel causes gum and varnish. This creates deposits on engine valves and in carburetor jets and passages. This is what causes most of the performance problems.
2. Oxygenated (or blended) fuels can deteriorate faster and require more specific storage and usage procedures.
3. The translucent fuel tanks on some model tractors allow a certain amount of sunlight through the tank. This can accelerate the deterioration of the fuel.



**Caution: Avoid Injury! Fuel stabilizer is a hazardous chemical and can be harmful or fatal if swallowed. Do not take internally. Avoid contact with eyes. Avoid breathing the chemical vapors.**

**Read safety instructions on stabilizer container label before using.**

**Fuel stabilizer contains 2,6-di-tert-butylphenol (128-39-2) and aliphatic petroleum distillate (64742-47-8). In case of emergency, contact a physician immediately and call 1-800-424-9300 for material safety information.**

**Note: There is no fuel stabilizer made that will "restore" stale fuel. Fill tanks with fresh, stabilized fuel.**

4. Use fuel from a major name brand supplier. At the same time, add an appropriate amount of Fuel Stabilizer (such as TY25808). Do this when you add fresh fuel to your tank.
5. If engine performance problems arise, try another brand of fuel. You may have to try several different sources.
6. Any fuel over 30 days old is considered "stale".
  - For 2-cycle equipment, purchase as small a quantity of fuel as feasible. If there is doubt about how long the fuel may be stored, add stabilizer right away. JOHN DEERE PREMIUM EXACT MIX 2-Cycle Oil (UP08127) already has a fuel stabilizer added to the oil. When using this oil fuel mix, it will stay fresh for up to 30 days. If storing a 2-cycle powered unit for more than 3 weeks, it is recommended to run the fuel out of the unit.

## Tests and Adjustments

### Throttle Cable Check and Adjustment

#### Reason:

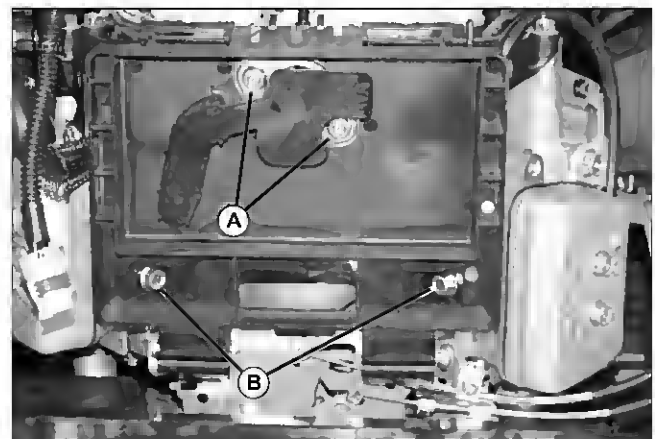
- To make sure the throttle control arm has the proper amount of travel for maximum engine performance.

#### Equipment:

- 6 mm (1/4-in.) Bolt or Drill Bit

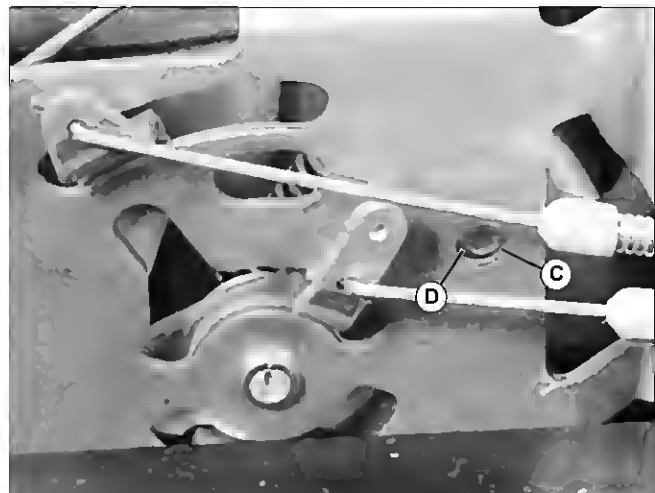
#### Check Procedure:

1. Park machine safely. See "Park Machine Safely" in the Safety section.
2. Remove air filter cover and air filter.



MX37067

3. Remove the two flanged shoulder bolts (B) and two nuts (A) that hold the air cleaner base to the carburetor.
4. Move throttle control lever from SLOW idle to FAST idle position.



MX37638

5. Check hole alignment in control panel (C) and throttle arm (D) by placing 6mm (1/4-in.) bolt or drill bit in hole. Bolt

# ENGINE - KAWASAKI (FH491V) TESTS AND ADJUSTMENTS

must go through both holes.

## Results:

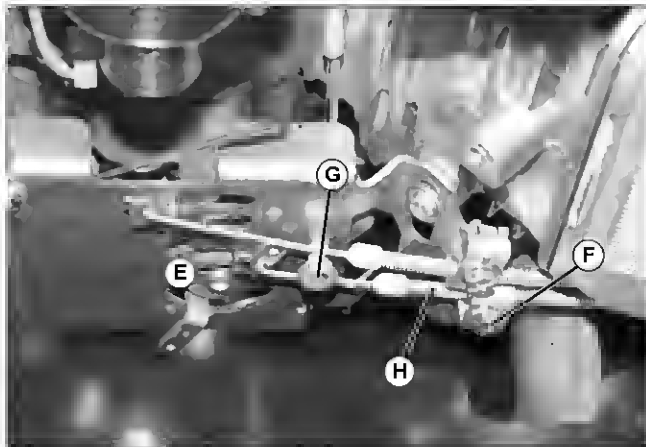
- If holes align throttle cable adjustment is OK.
- If holes DO NOT align, perform "Adjustment Procedure" below.

## Adjustment Procedure:



**Caution: Avoid Injury! Engine components are HOT. Do not touch, exhaust pipe or muffler while making adjustments.**

1. Move throttle control lever to FAST.



MX38033

2. Loosen cable retainer screw (F).
3. Move throttle arm (E) and throttle cable (H) to align holes in control panel and throttle control plate. Insert a 6 mm (1/4 in.) bolt (G) or drill bit through holes to keep throttle arm from moving. Be sure bolt or drill bit is perpendicular to the control panel.
4. Make sure throttle control lever on dash is still in FAST position. Tighten retaining screw (F).
5. Remove bolt or drill bit.
6. Repeat "Check Procedure".
7. Move throttle control lever through full range to be sure linkage is not binding.
8. Install air filter housing and air filter.

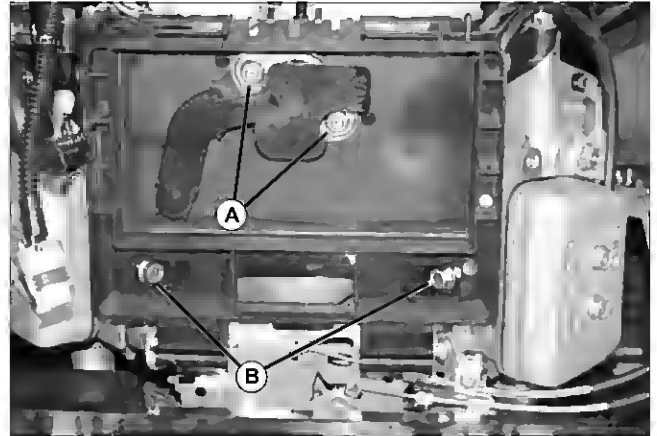
## Choke Cable Adjustment

### Reason:

To make sure the choke is fully closed when the choke control lever is in the full choke position.

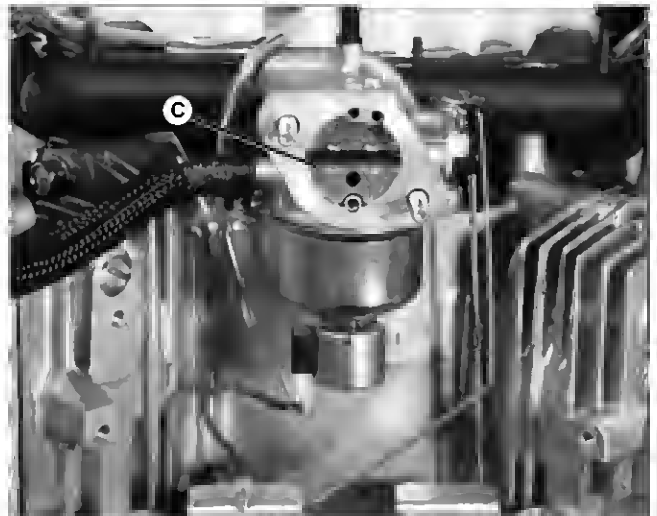
### Procedure:

1. Park machine safely. See "Park Machine Safely" in the Safety section.
2. Remove hood.
3. Remove air filter cover and air filter.



MX37067

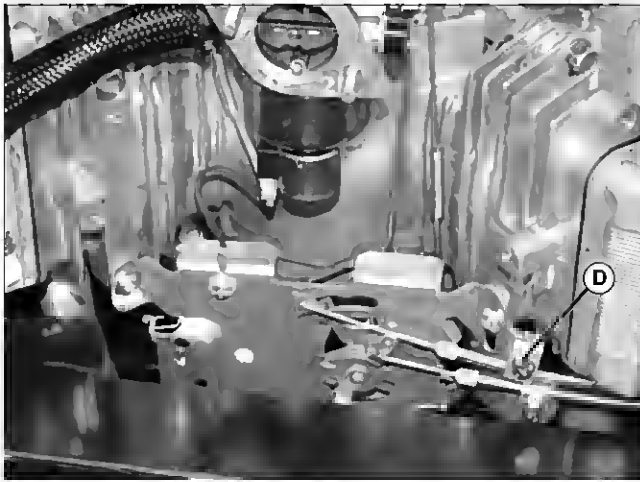
4. Remove the two flanged shoulder bolts (B) and two nuts (A) that hold the air cleaner base to the carburetor.



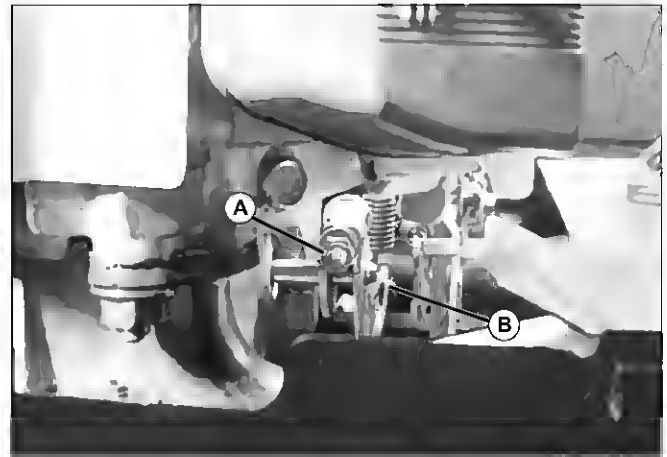
MX37070

5. Move the engine choke lever to the choke position. The carburetor choke butterfly (C) should be fully closed.

# ENGINE - KAWASAKI (FH491V) TESTS AND ADJUSTMENTS



MX37071



MX37639

6. If the choke butterfly does not completely close, loosen cable clamp (D). Adjust position of choke cable to completely close choke.

7. Move the choke control lever between the choke fully open and fully closed position several times. Ensure the choke plate fully opens and closes. Readjust cable as needed.

**Installation is done in the reverse order of removal.**

- Tighten fasteners to specification.
- Install hood.

## Torque Specifications:

**Air Cleaner Base Nuts** ..... 6.9 N•m (61 lb-in.)

**Air Cleaner Base Screws** ..... 3.9 N•m (35 lb-in.)

## Governor Adjustment

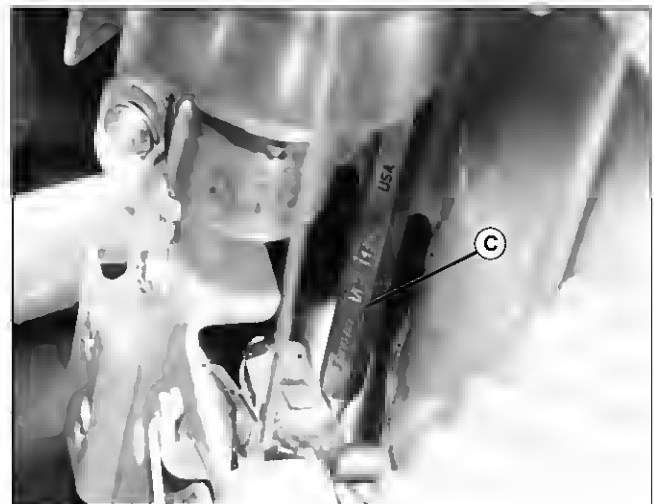
### Reason:

To ensure the governor shaft contacts the flyweight plunger when the engine is stopped.

### Procedure:

1. Park machine safely. See "Park Machine Safely" in the Safety section.
2. Move throttle control lever to FAST idle position.

3. Loosen nut (A).



MX37640

4. Insert small pin punch (C) in hole in governor shaft.
5. Hold governor arm (B) in the fully counterclockwise position.
6. Rotate governor shaft counterclockwise as far as it will go.
7. Hold governor shaft and governor arm in place and tighten nut to specification.
8. Move throttle control lever through full range to be sure linkage is not binding.

### Specification:

**Torque** ..... 7.8 N•m (69 lb-in.)

# ENGINE - KAWASAKI (FH491V) TESTS AND ADJUSTMENTS

## Slow Idle Speed Adjustment

### Reason:

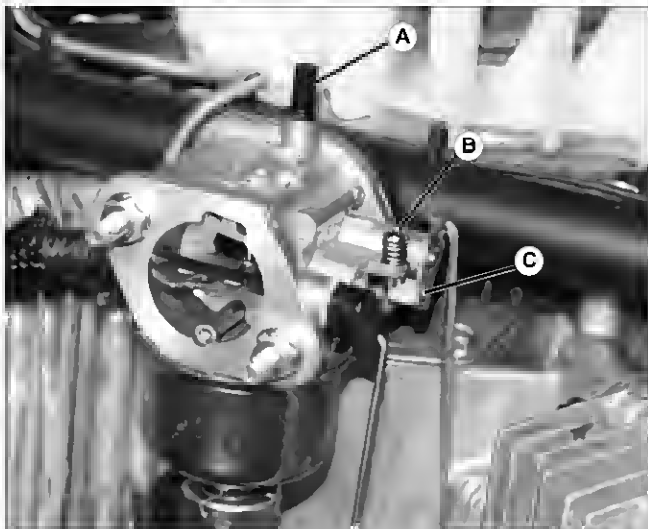
To set engine slow idle rpm.

### Equipment:

- JTO7270 Digital Pulse Tachometer, or
- JT05719 Photo Tachometer

### Procedure:

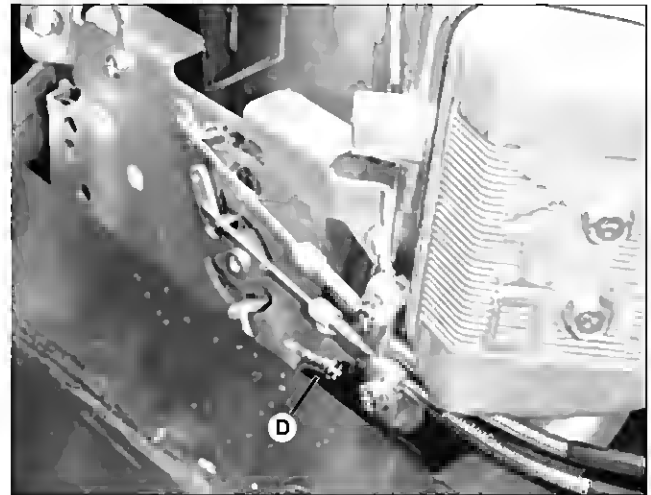
1. Park machine safely. See "Park Machine Safely" in the Safety section.
2. If using photo tachometer, put reflective tape on blower housing screen.



**Picture Note:** Air Filter and Housing Removed for Clarity

3. Start and run engine at MEDIUM idle for five minutes.
4. Move throttle control lever to SLOW idle position.
5. Turn idle mixture screw (A) until best idle is obtained.
6. Push throttle lever closed so that tab (C) is against idle stop screw (B).
7. Turn SLOW idle stop screw until engine rpm is set at 1450 rpm.

**Note:** Idle speed is governed at  $1850 \pm 100$  rpm. When throttle lever is released, the idle speed will increase.



8. Release the throttle lever and check the governed SLOW idle rpm.

**Note:** Be sure idle stop screw on the control panel is in contact with throttle arm when making adjustments.

9. Adjust idle stop screw (D) on the control plate to obtain specified governed slow idle.

### Specification:

Slow Idle .....  $1850 \pm 100$  rpm

## Fast Idle Speed Adjustment

### Reason:

To set engine fast idle speed setting.

### Equipment:

- 6 mm (15/64 in.) Drill Bit
- JTO7270 Digital Pulse Tachometer; or,
- JT05719 Photo Tachometer

### Procedure:

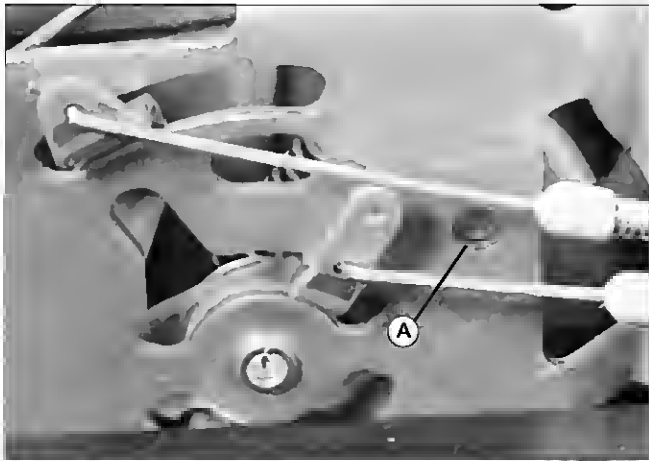
1. Park machine safely. See "Park Machine Safely" in the Safety section.
2. If using photo tachometer, put reflective tape on blower housing screen.
3. Start and run engine at MEDIUM idle for five minutes.



**Caution:** Avoid Injury! Engine will be HOT. Be careful not to burn hands.

4. Move throttle control lever to FAST idle position.

# ENGINE - KAWASAKI (FH491V) TESTS AND ADJUSTMENTS



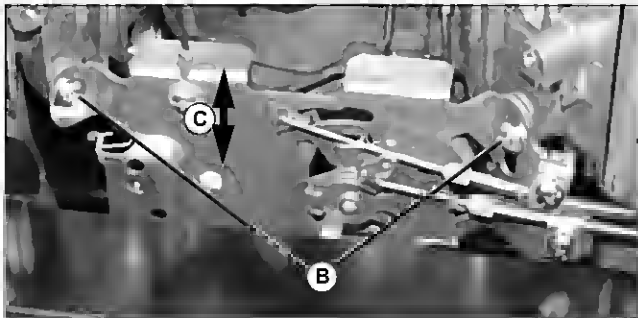
MX37638

5. Align holes in throttle arm and throttle control bracket (A). Place a 6 mm (1/4-in.) drill bit through holes to keep the throttle control arm from moving. Be sure drill bit is perpendicular to the throttle control panel.

6. Use tachometer to check engine rpm. Fast idle speed setting should be to specification.

## Results:

If fast idle speed does not meet the specifications:



MX37644

1. Loosen cap screws (B).
2. Move throttle control panel (C) up to increase rpm or down to decrease rpm.
3. Hold the throttle control panel and tighten cap screws to specification.
4. Remove the drill bit.

## Specification:

Fast Idle Speed ..... 3350  $\pm$  100 rpm  
Control Panel Screw Torque ..... 5.9 N·m (52 lb-in.)

## Valve Clearance, Check and Adjustment

### Reason:

To obtain the proper valve clearance that is critical for the valves to seat properly.

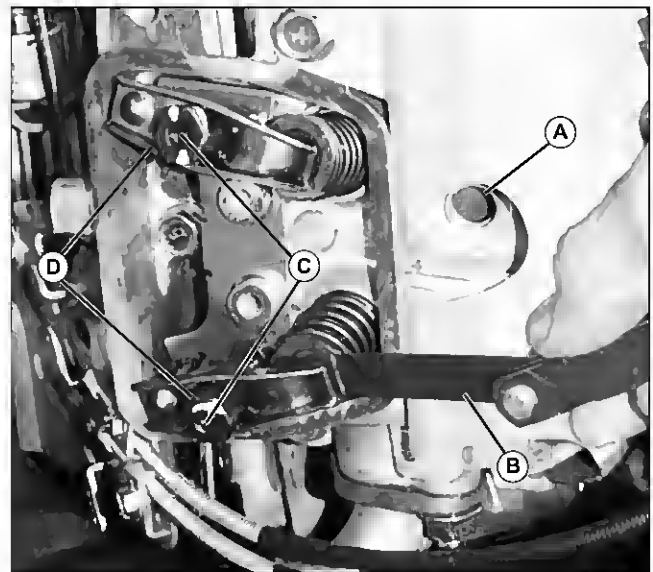
### Equipment:

- Feeler Gauge

### Procedure:

**Important: Avoid Damage! Perform valve clearance check or adjustment when engine is cold.**

1. Park machine safely . See "Park Machine Safely" in the Safety section.
2. Allow engine to cool.
3. Remove and ground both spark plug leads. Remove spark plugs.
4. Remove valve cover.



MX37643

5. Turn crankshaft until piston, visible in spark plug hole (A), is at TDC (top dead center) of the compression stroke (both intake and exhaust valves will be closed).
6. Use a feeler gauge (B) to measure valve clearance. Valve clearance should be within specification.

## Results:

1. If valve clearance does not meet specification, loosen lock screws (C). Turn adjusting nut (D) to adjust valve clearance to specifications.
2. Hold adjusting nut and tighten lock screw to specification. Check clearance again.

# ENGINE - KAWASAKI (FH491V) TESTS AND ADJUSTMENTS

## Specifications:

Valve Clearance (Intake and Exhaust) (Cold)... 0.075 - 0.125 mm (0.003 - 0.005 in.)

Jam Nut Torque ..... 6.9 N•m (61 lb-in.)

Valve Cover Cap Screw Torque..... 6.9 N•m (61 lb-in.)

Spark Plug Torque ..... 22 N•m (195 lb-in.)

## Cylinder Leak-Down Test

### Reason:

To determine if compression pressure is leaking from cylinder.

### Test Equipment:

- JTO3502 Compression Leakdown Tester

### Procedure:

1. Start engine. Run for 5 minutes to bring it up to normal operating temperature.
2. Park machine safely. See "Park Machine Safely" in the Safety section.



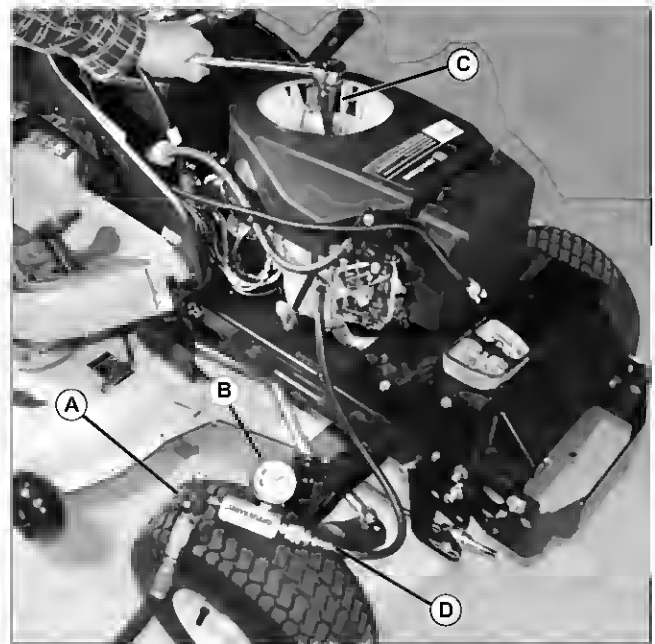
**Caution: Avoid Injury! Engine components are HOT. Be careful not to touch, especially the exhaust pipe or muffler while making adjustments. Wear protective eye glasses and clothing.**

3. Remove spark plugs.
4. Remove rocker arm covers.

**Note: The crankshaft must be held with the piston just slightly past TDC to seal the combustion chamber and eliminate the chance of rotation. Screw the adapter hose (D) into the spark plug hole, but do not attach it to the tester at this time.**

5. Turn crankshaft until piston, visible in spark plug hole, is at TDC of the compression stroke (both intake and exhaust valves will be closed).

**Note: The air supply must have enough supply pressure to calibrate the tester, usually 585 - 655 kPa (85 - 95 psi).**



MX37646

6. Connect tester port to an air source.

**Note: Air leaks at any of the connections or fittings of the tester will affect the accuracy of the test.**

7. Pull back the locking ring and slowly rotate the regulator adjustment knob (A) until the gauge needle is in the SET range of the gauge (B). Push the locking ring towards the tester to lock knob in position.



**Caution: Avoid Injury! Injury can occur if the crankshaft is not locked in position. The air source can create a rotational force of up to (81 N•m) 60 lb-ft if the crankshaft is not locked with the piston slightly past top dead center.**

8. Have an assistant hold the crankshaft in position with socket and breaker bar (C). Connect the adapter hose (D) to the tester, and record the needle position.

**Note: A small amount of air escaping from the crankcase breather is normal. If a high flow of air is leaking from the exhaust or carburetor areas, make sure that piston is just slightly past TDC of the compression stroke.**

9. Observe reading on gauge. Listen for air leaking from the cylinder head gasket, carburetor, exhaust system and either the crankcase breather or oil fill/ dipstick tube.

### Results:

- Gauge reading in the Green (low) area indicates good compression. (Less than 25% leakage is considered normal).



# ENGINE - KAWASAKI (FH491V) TESTS AND ADJUSTMENTS

- Gauge reading in the Yellow (Moderate) area indicates borderline compression. The engine is still usable but an overhaul or replacement should be considered.
- Gauge reading in the Red (High) area indicates excessive compression loss. Engine reconditioning or replacement is necessary.
- Check air escaping from muffler, air cleaner or oil fill opening.
- Excessive air escaping from the crankcase breather indicates worn piston rings or cylinder wall.
- Air escaping from the carburetor indicates a worn intake valve or seat.
- Air escaping from the exhaust pipe indicates a worn exhaust valve or seat.
- Repeat test on other cylinder.

## Cylinder Compression Pressure Test

### Reason:

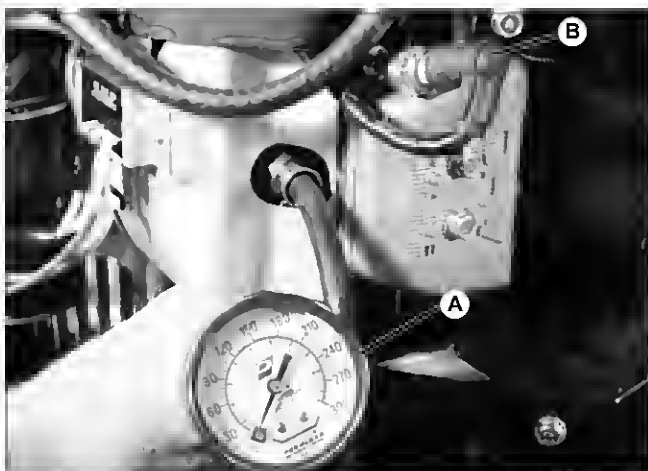
To determine the condition of the pistons, rings, cylinder walls, and valves.

### Test Equipment:

- JDM59 Compression Gauge

### Procedure:

1. Valve clearance must be adjusted properly before doing a compression test.
2. Run engine for five minutes to bring engine to operating temperature.
3. Park machine safely. See "Park Machine Safely" in the Safety section.
4. Remove spark plugs.



MX37645

5. Install JDM59 compression gauge (A) in one spark plug

hole.

6. Ground high tension leads.
7. Move throttle control lever to FAST idle position.
8. Check that choke is fully open and that air filter is clean.

**Important: Avoid Damage! DO NOT overheat starting motor during test. Starting motor duty cycle is 5 seconds ON, 10 seconds OFF.**

9. Crank engine for three to five compression strokes.
10. Record pressure reading.
11. Repeat test with other cylinder.

### Results:

**Note: Specification is for an engine that has sufficient time to allow rings to fully seat. Compression that is lower than specifications on low hour machines (but relatively equal on both cylinders) probably does not indicate a problem.**

- If above specification, adjust valves and check fuel and air intake systems. Check exhaust for restriction.
- If below specification, squirt clean engine oil into cylinder and repeat test.
- If compression pressure DOES NOT increase after retest; check for leaking valves, valve seats, or cylinder head gaskets.
- If compression pressure INCREASES after retest; check rings, pistons, and cylinder bores for broken rings, scoring, wear or damage. Replace as necessary.

## Crankcase Vacuum Test

### Reason:

To measure the amount of crankcase vacuum, which ensures the crankcase is not pressurized. A pressurized crankcase will force oil leakage past the seals and gaskets and affect fuel pump operation.

### Test equipment:

JT03503 Vacuum Gauge

### Procedure:

**Important: Avoid Damage! DO NOT make connection between test gauge and rubber plug BEFORE engine is running at FAST idle or gauge damage may result**

1. Park machine safely. See "Park Machine Safely" in the Safety section.
2. Remove dipstick.

# ENGINE - KAWASAKI (FH491V) TESTS AND ADJUSTMENTS

3. Install appropriate size ported rubber plug in dipstick tube.
4. Insert barbed fitting into clear line and attach to gauge.
5. Hold finger over rubber plug hole to keep oil from spraying out. Start engine and run at FAST idle.
6. Connect gauge, clear line, and barbed fitting to rubber plug.
7. Record crankcase vacuum reading. Gauge should show a minimum vacuum of **25 cm (10 in.)** of water movement.

**Important: Avoid Damage! After test reading is made, DO disconnect test gauge WHILE engine is running at FAST idle to prevent damage to gauge.**

8. Disconnect barbed fitting, clear line, and gauge from rubber plug while engine is running at FAST idle. Hold finger over rubber plug hole to keep oil from spraying out.
9. Move throttle to SLOW idle and turn engine OFF.
10. Remove rubber plug and install dipstick.

## Results:

If crankcase vacuum is BELOW specification, check the following:

- Breather port is obstructed.
- Condition of breather valve.
- Rings, piston, and cylinder bore for wear or damage.

## Engine Oil Pressure Test

### Reason:

To verify if the engine has enough oil pressure to lubricate internal components.

### Test Equipment:

- JT03344 Pressure Gauge Assembly
- JT03017 Hose Assembly
- JT03349 Connector

### Procedure:

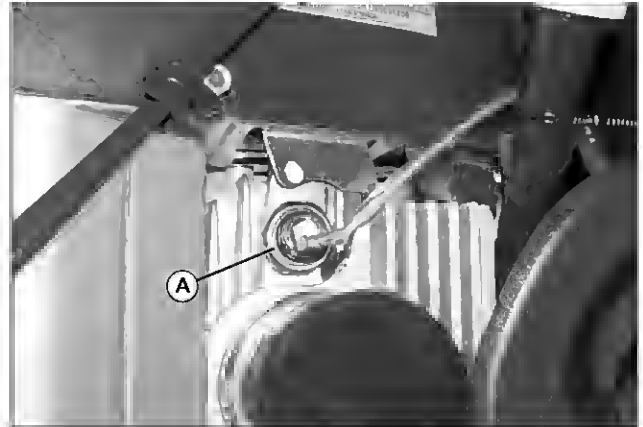
1. Park machine safely. See "Park Machine Safely" in the Safety section.



**Caution: Avoid Injury! Engine components are HOT. Be careful not to touch, especially the exhaust pipe or muffler while making adjustments. Wear protective eye glasses and clothing.**

2. Allow engine to cool.

3. Check engine oil level, bring level to full mark.



MX36441

4. Remove oil pressure switch (A).
5. Install JT03349 Connector.
6. Connect JT03017 hose assembly and JT03344 pressure gauge assembly.
7. Monitor oil pressure while cranking engine. If no oil pressure is present, discontinue cranking engine. Determine and correct cause before running engine.

**Important: Avoid Damage! If pressure reading is below 69 kPa (10 psi), STOP ENGINE IMMEDIATELY and determine cause.**

8. Start and run engine at MEDIUM idle for five minutes to heat engine oil to normal operating temperature.
9. Run engine at fast idle and check oil pressure.

**Note: Use silicon sealer on switch threads.**

10. Remove test equipment and install oil pressure switch. Tighten switch to specification.

## Results:

If oil pressure is BELOW specifications, inspect or replace the following:

- Oil filter plugged.
- Oil pressure relief valve for broken or worn spring.
- Oil pressure relief valve for stuck or damaged valve.
- Worn or damaged oil pump.
- Oil pump suction screen or oil passages plugged.
- Excessive wear of connecting rod and main bearing journals.

## Specifications:

Oil Pressure Minimum . . . . . 69 kPa (10 psi)  
Oil Pressure at Fast Idle . . . . 240 - 310 kPa (35 - 45 psi)  
Switch Torque. . . . . 9.8 N•m (87 lb-in.)

# ENGINE - KAWASAKI (FH491V) TESTS AND ADJUSTMENTS

## Fuel Pump Test

### Reason:

To check condition of fuel pump and determine fuel pressure.

### Test Equipment:

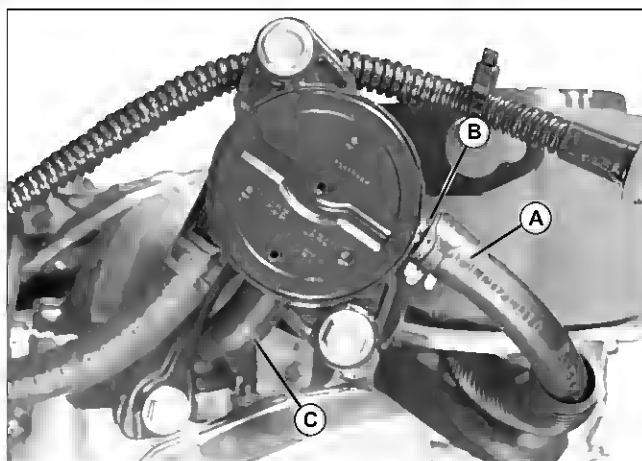
- JDG356 Pressure Gauge
- Graduated Container

### Procedure:

1. Park machine safely. See "Park Machine Safely" in the Safety section.



**Caution: Avoid Injury! Gasoline is extremely flammable. DO NOT SMOKE. Always work in a well ventilated area away from open flame or spark producing equipment; this includes equipment that utilizes pilot lights.**



MX36435

2. Disconnect and plug fuel pump outlet hose (A).
3. Connect JDG356 pressure gauge to fuel pump outlet (B).
4. Start and run engine at fast idle for 15 seconds, then record pressure reading.
5. Stop engine.
6. Remove pressure gauge from fuel pump outlet and connect a length of hose long enough to reach into a graduated container.
7. Start and run engine at fast idle for 15 seconds, then stop the engine and record container measurement.

### Results:

If fuel pump pressure or flow does not meet the specifications, check the following:

- Fuel lines, vacuum line (C), fuel filter and fuel tank cap for restrictions.
- Check fuel pump vent holes for obstruction.
- Check crankcase vacuum.
- Replace fuel pump.

### Specifications:

**Fuel Pump Pressure (Slow Idle) . . . . 2.45 kPa (0.36 psi)**

**Minimum Fuel Flow . . . . . 65 mL (2.2 oz)/15 seconds**

## Spark Test

### Reason:

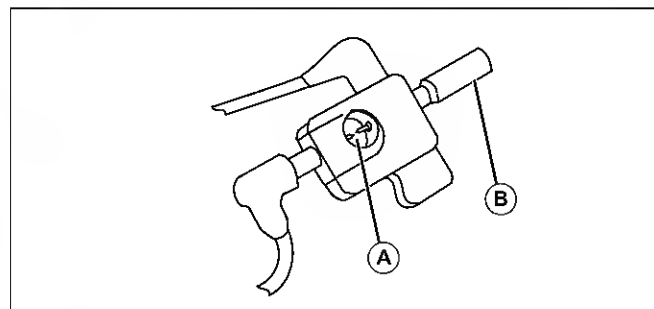
Check overall condition of ignition system.

### Test Equipment:

- D-05351ST Spark Tester

### Procedure:

1. Park machine safely. See "Park Machine Safely" in the Safety section.



MIF

2. Remove high tension lead from spark plug.
3. Connect D-05351ST spark tester to spark plug.
4. Connect high tension lead to spark tester.

**Important: Avoid Damage! Do not adjust spark tester gap beyond 5.0 mm (0.200 in.) (5 turns), as damage to ignition components could occur.**

5. Adjust spark tester gap (A) to 4.2 mm (0.166 in.) (4 turns) with screw (B).
6. Move key switch to RUN position.
7. Spin engine with starter and watch spark at spark tester. If engine will start, watch spark with engine running. A steady, strong, blue spark should be observed.
8. Repeat test on other cylinder.

# ENGINE - KAWASAKI (FH491V) TESTS AND ADJUSTMENTS

## Results:

- If spark is weak, or no spark is present, install a new spark plug and repeat test.
- If spark is still weak, or no spark is present, run tests on individual components to find the cause of the malfunction.

## Spark Plug Gap

### Equipment:

- Feeler Gauge, or
- Wire Gauge

### Procedure:

1. Park machine safely. See "Park Machine Safely" in the Safety section.



**Caution: Avoid Injury! Engine components may be HOT. Be careful not to touch, especially the exhaust pipe or muffler while making adjustments.**

2. Remove spark plugs.
3. Inspect each spark plug for cracked porcelain and pitted or damaged electrodes.
4. Check spark plug gap using a feeler or wire gauge. Set gap to specification.
5. Install and tighten spark plug to specification.

### Specifications:

**Spark Gap** ..... 0.76 mm (0.030 in.)

**Spark Plug Torque** ..... 22 N•m (195 lb-in.)

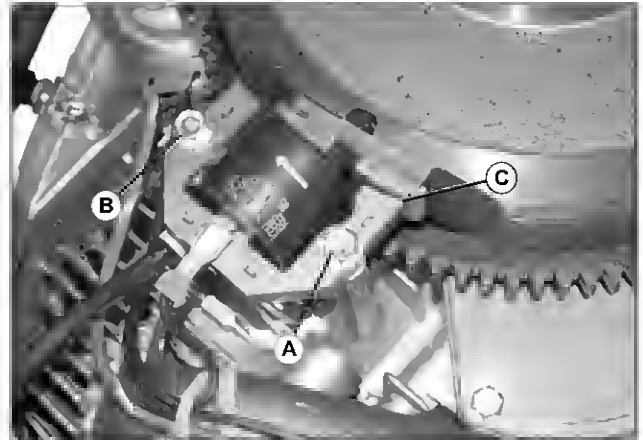
## Ignition Coil Air Gap Adjustment

### Equipment:

- Feeler Gauge

### Procedure:

1. Center flywheel magnet under one armature leg and coil.



MX36428

2. Insert a 0.30 mm (0.012 in.) feeler gauge between flywheel and armature (C).
3. Loosen screws (A) and (B) and push armature against feeler gauge. Tighten cap screw (A).
4. Turn flywheel to center flywheel magnet under coil and second armature leg.
5. Repeat setting air gap for second armature. Tighten cap screw (B).
6. Rotate flywheel fully around and check both air gap measurements.
7. Tighten cap screws to specification.

### Specifications:

**Ignition Coil Air Gap** .... 0.25 - 0.40 mm (0.010 - 0.016 in.)

**Cap Screw Torque** ..... 5.9 N•m (52 lb-in.)

# ENGINE - KAWASAKI (FH491V) REPAIR

## Repair

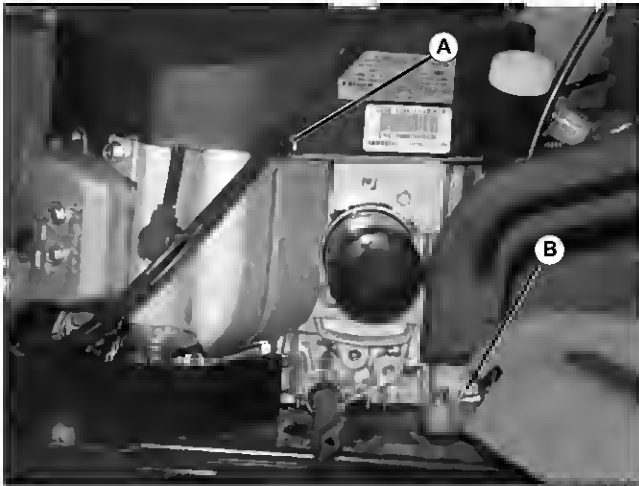
### Engine Removal and Installation

#### Removal:



**Caution: Avoid Injury! Engine components may be HOT. Allow engine to cool before removing engine.**

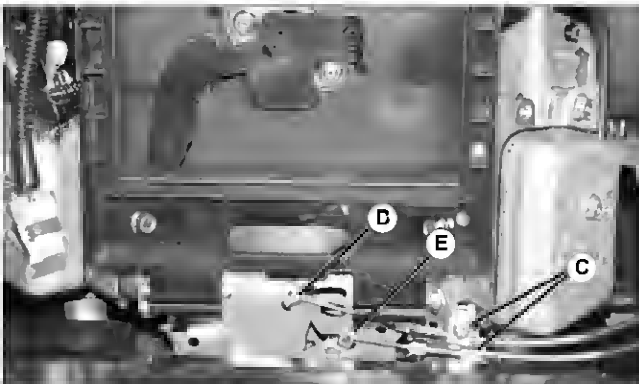
1. Park machine safely on level surface. See "Park Machine Safely" in the Safety section.
2. Disconnect negative (-) cable from battery.
3. Remove mower deck.
4. To aid engine removal and installation remove the left side hood bracket.



MX37684

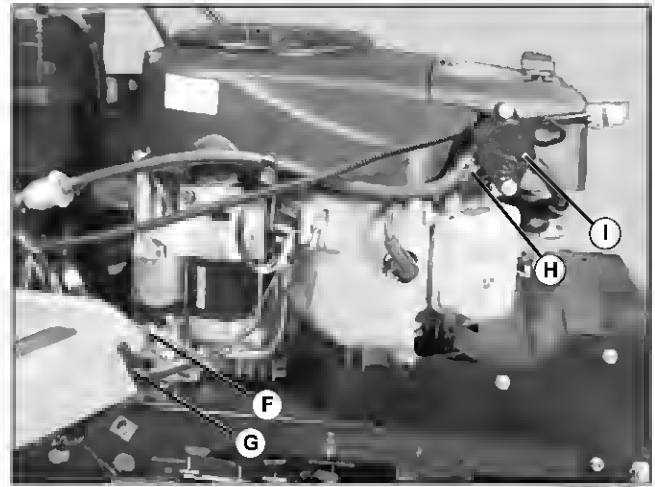
#### Picture Note: Left Side

5. Disconnect cable clamp (A). Ground wire (B) will be removed when engine mounting bolts are removed.



MX37067

6. Remove screws and cable retainers (C).
7. Unhook throttle cable (D) and choke cable (E).



MX37057

#### Picture Note: Right Side

8. Disconnect battery positive (+) cable (F) to starting motor solenoid.
9. Disconnect engine wire harness connector (G).



**Caution: Avoid Injury! Gasoline is extremely flammable. DO NOT SMOKE. Always work in a well ventilated area away from open flame or spark producing equipment; this includes equipment that utilizes pilot lights.**

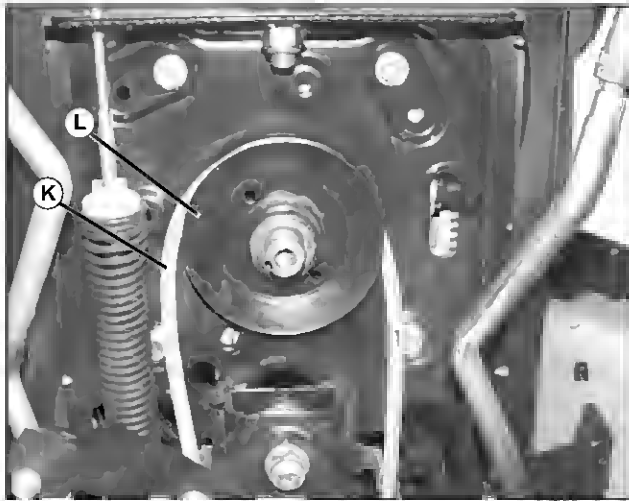
10. Disconnect and plug fuel hose (H) from fuel pump (I).
11. Remove electric PTO clutch. See "PTO Clutch Removal and Installation" on page 394 in Power Train Section.
12. Remove Muffler. See "Muffler Removal and Installation" on page 58.



MX37048

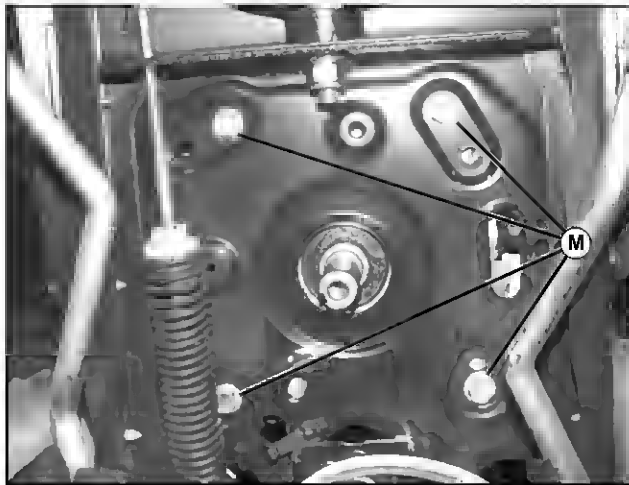
13. Disconnect traction belt tension spring (J).

## ENGINE - KAWASAKI (FH491V) REPAIR



MX37050

14. Remove drive belt (K) from drive sheave (L).
15. Remove drive sheave from end of crankshaft.



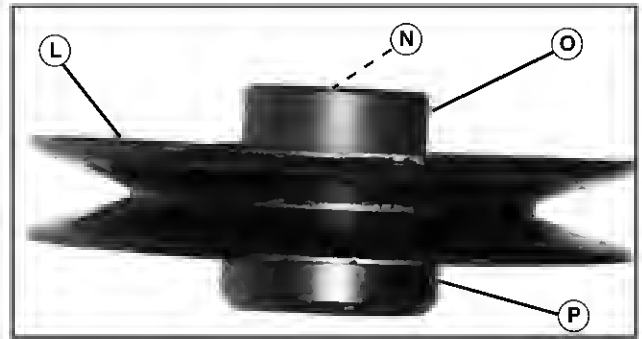
MX37049

16. Remove four mounting cap screws (M).
17. Remove engine.

### Installation:

Installation is done in the reverse order of removal.

1. Install four engine mounting cap screws (N). Be sure to connect the ground wire to the left rear mounting cap screw. Tighten cap screws and lock nuts to specifications.
2. Apply MPG-2 Multipurpose Polymer Grease to engine crankshaft.



MX37051

3. Install traction drive sheave (L with key (N)). Be sure to install small hub (O) against engine and large hub (P) to clutch.
4. Install belt (K).
5. Install traction belt tension spring (J).
6. Install electric PTO clutch. See "PTO Clutch Removal and Installation" on page 394 in Power Train Section.
7. Connect the fuel line to the fuel pump.
8. Connect the battery cable to the starting motor.
9. Connect the engine wire harness to main wiring harness.
10. Connect the throttle cable and choke cable.
11. Adjust throttle cable and choke plate. See "Throttle Cable Check and Adjustment" on page 43.
12. Install muffler.
13. Check oil level.

### Specifications:

**Engine Mounting Cap Screw Torque . . 34 N•m (25 lb-ft)**  
**Oil Capacity w/ Filter (Approximate) . . . . . 1.8 L (1.9 qt)**

# ENGINE - KAWASAKI (FH491V) REPAIR

## Air Cleaner Assembly

**Important: Avoid Damage!** Any time the air cleaner is removed, check for free choke operation during reassembly.

1. Remove and disassemble air cleaner.

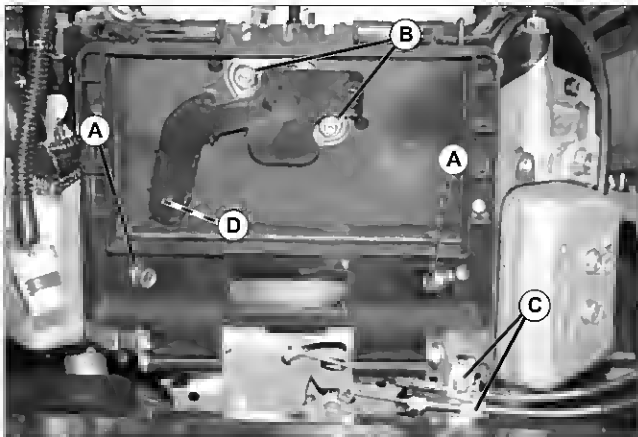
**Important: Avoid Damage!** Do not clean paper element with solvent or compressed air.

2. Gently tap paper element to remove dust.
3. Inspect element.
  - Element is still usable if you can see light through it and element appears clean.
  - Replace if oily, dirty, or damaged in any way.
4. Inspect cover, gasket, and base for damage. Replace parts as necessary.
5. Assemble and install air cleaner.

## Carburetor Removal, Disassembly, and Installation

### Removal:

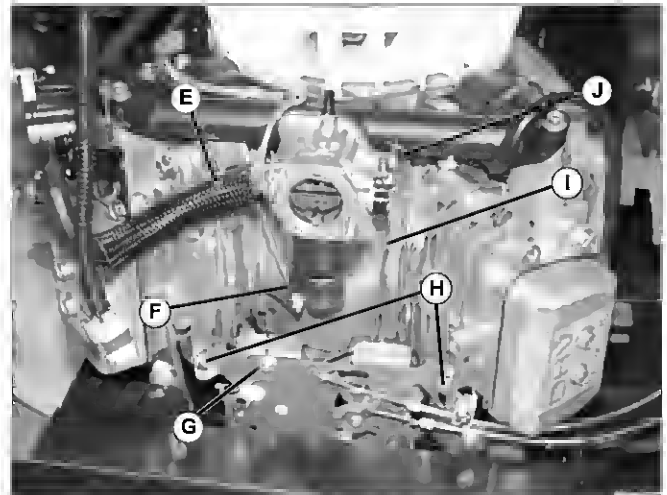
1. Unsnap and remove air cleaner cover and air filter.



2. Remove the two flanged shoulder bolts (A) and two nuts (B) that hold the air cleaner base to the carburetor.
3. Carefully pull air cleaner base away from carburetor and remove crankcase vent tube (D) from back of air cleaner base.



**Caution: Avoid Injury!** Gasoline is extremely flammable. Do not smoke. Always work in a ventilated area away from open flame or spark producing equipment, including equipment that utilizes pilot lights.



4. Remove and plug the fuel inlet hose (E).
5. Disconnect wire connector (F) to the fuel shutoff solenoid and wire connector (G) grounding the fuel shutoff solenoid.
6. Mark the two screws (H) position in the slots on the control panel. This will give a close starting position for setting high idle speed later. Remove the screws.
7. Carefully pull the control panel away from engine and disconnect the governor spring and choke rod from the control panel.
8. While pulling the carburetor forward disconnect the choke rod (I) and then the throttle link and throttle spring (J) from the carburetor.

**Note: Governor rod spring and governor rod go in same hole in throttle shaft arm on carburetor.**

**Installation is done in the reverse order of removal.**

- Tighten fasteners to specification.
- Check low and high idle speed settings and adjust if necessary.

### Torque Specifications:

Ground Screw . . . . .	3.4 N•m (30 lb-in.)
Control Panel Mounting Screws . . . .	6.9 N•m (61 lb-in.)
Air Cleaner Base Nuts . . . . .	6.9 N•m (61 lb-in.)
Air Cleaner Base Screws . . . . .	3.9 N•m (35 lb-in.)

# ENGINE - KAWASAKI (FH491V) REPAIR

## Disassembly:



**Caution: Avoid Injury!** Gasoline is extremely flammable. Do not smoke. Always work in a ventilated area away from open flame or spark producing equipment, this includes equipment that utilizes pilot lights.

**Important: Avoid Damage!** To remove float, use a long nosed pliers on end of pin (25). Do not strike opposite end of pin. Damage to pin holder may result.

1. Refer to component illustration shown for disassembly, assembly and component location.
2. There are several passage plug balls in carburetor body. DO NOT remove these plugs.
3. When removing the pilot air screw (#2), carefully mark the position of the air screw limiter on the carburetor body so that it can be installed and set to its original position later.
4. Remove limiter. Be careful not to turn pilot air screw at this point.
5. Turn the pilot air screw clockwise and count the number of turns until screw is gently seated in the pilot passage.
6. Record the number of turns needed to close the pilot air screw.
7. Turn out the pilot air screw and replace with a new one.

## Clean/Inspect/Rebuild:

**Important: Avoid Damage!** Do not clean holes or passages with small drill bits or wire.

**Note: If all rubber and plastic parts cannot be removed for cleaning, use a cleaning solvent with a high flash point that will not damage these parts when cleaning.**

1. Remove rubber and plastic parts from carburetor. Soak all carburetor metal parts in carburetor cleaning solvent for 1/2 hour maximum.
2. Spray all passages with a carburetor cleaning spray to verify that all internal passages are open.



**Caution: Avoid Injury!** Reduce compressed air to less than 210 kPa (30 psi) when using for cleaning purposes. Clear area of bystanders, guard against flying chips, and wear personal protection equipment including eye protection.

**Important: Avoid Damage!** Rinse carburetor body in warm water to neutralize corrosive action of cleaner on aluminum.

3. Rinse carburetor with warm water and dry with compressed air. Do not use rags or paper to dry parts; lint may plug holes or passages.
4. Inspect all parts for wear or damage, replace as necessary.

**Note: Main jet high altitude kits are available.**

## Assembly:

1. Install new pilot air screw until screw is gently seated.
2. Then open the screw the same number of turns as recorded prior to removal.
3. Align the limiter with the mark on the carburetor body to install, taking care not to turn the pilot air screw.
4. Install the throttle valve on the shaft with numerical mark on the valve facing to the outside.
5. Note the metering hole in the choke valve. Install the choke valve on the shaft so that the metering hole is towards outside of the carburetor.
6. Install the float pin so that it's big diameter side faces the engine flange side. Float is plastic. The float cannot be adjusted. Replace if necessary.
7. Tighten all fasteners to specifications listed.

## Specifications:

Choke Valve Screws	0.7 N•m (6 lb-in.)
Throttle Valve Screws	1.0 N•m (9 lb-in.)
Pilot Jet	1.7 N•m (15 lb-in.)
Main Jet	0.7 N•m (6 lb-in.)
Valve Seat	2.0 N•m (17 lb-in.)
Main Nozzle	2.0 N•m (17 lb-in.)
Main Air Jet	0.7 N•m (6 lb-in.)
Pilot Air Jet	0.7 N•m (6 lb-in.)
Drain Screw	1.3 N•m (11 lb-in.)
Fuel Shutoff Solenoid	6.9 N•m (61 lb-in.)



# ENGINE - KAWASAKI (FH491V) REPAIR

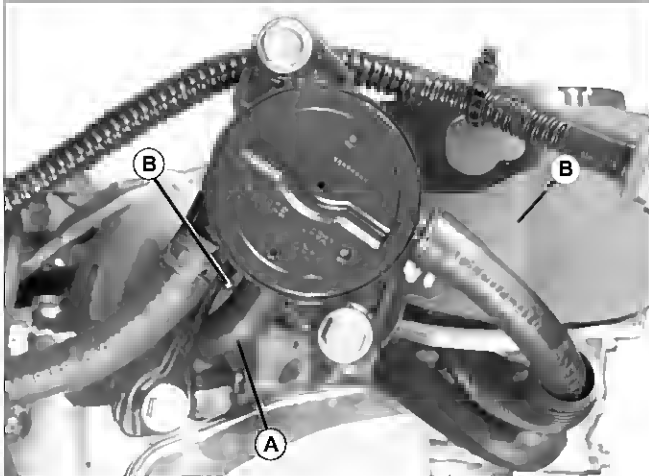
## Fuel Pump Removal and Installation

### Procedure:

1. Park machine safely. See "Park Machine Safely" in Safety section.



**Caution: Avoid Injury! Gasoline is extremely flammable. Do not smoke. Always work in a ventilated area away from open flame or spark producing equipment, this includes equipment that utilizes pilot lights.**



MX36435

2. Disconnect vacuum line (A) and fuel lines (B).
3. Remove two mounting screws.

### Installation:

Installation is done in the reverse order of removal.

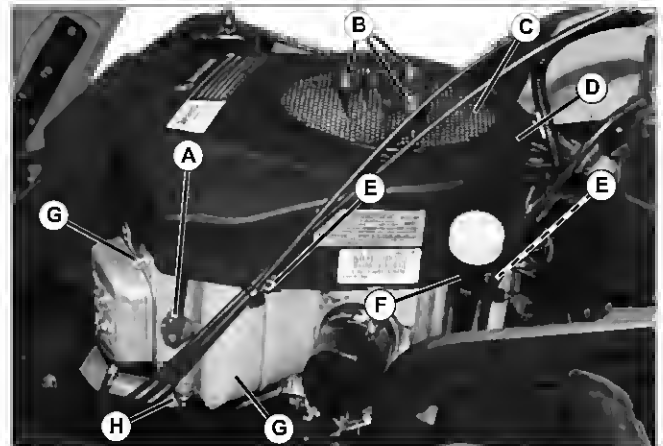
- Tighten mounting screws to specification.

### Specification:

**Torque** ..... 5.9 N•m (52 lb-in.)

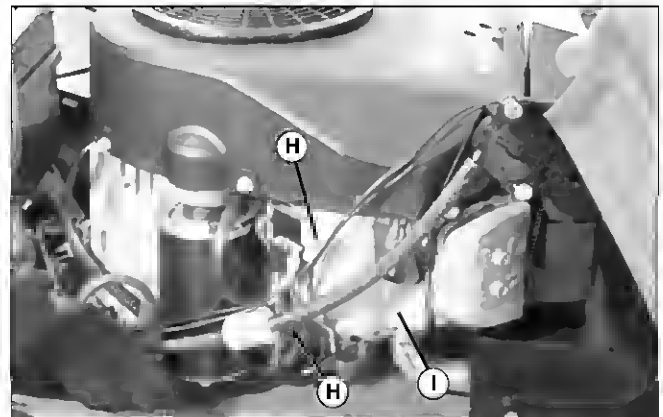
## Blower Housing Removal and Installation

### Removal:



MX37685

1. Disconnect spark plug caps (one on each side of engine) (A).
2. Remove three screws (B) securing the flywheel screen (C) to the flywheel. Remove flywheel screen.
3. Remove four screws (E) (two on each side) securing the upper blower housing (D) to the block and lower housings. Remove upper blower housing.
4. Remove two screws (H). Remove left side lower blower housing (G).
5. Remove dipstick tube (F).



MX14451

6. Remove two screws (J). Remove right side lower blower housing (I).

### Installation:

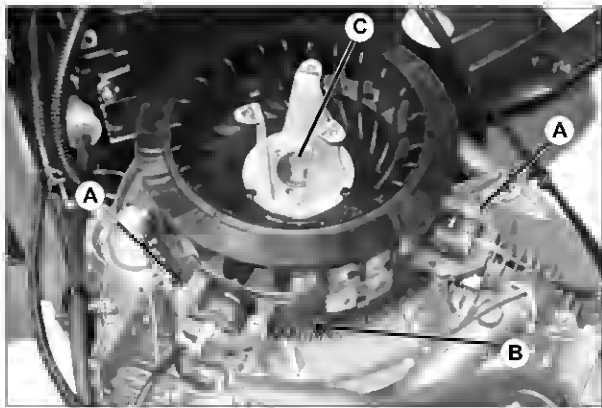
Installation is done in the reverse order of removal.

# ENGINE - KAWASAKI (FH491V) REPAIR

## Flywheel Removal and Installation

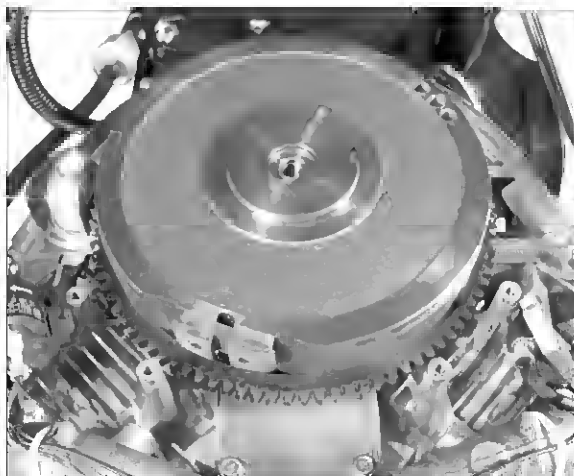
### Procedure:

1. Remove upper blower housing. See "Blower Housing Removal and Installation" on page 57.



MX36322

2. Remove both ignition coils (A).
3. Hold flywheel (B) and remove cap screw (C).



MX36436

4. Remove flywheel (B) using a flywheel puller.

**Installation is done in the reverse order of removal.**

- Tighten nut to **56 N•m (41 lb-ft)**.
- Adjust ignition coil air gap. See "Ignition Coil Air Gap Adjustment" on page 52.

## Muffler Removal and Installation

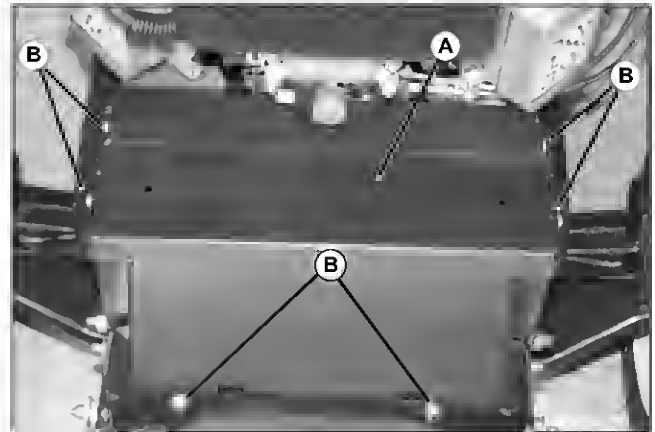
### Removal:

1. Park machine safely on level surface. See "Park Machine Safely" in the Safety section.



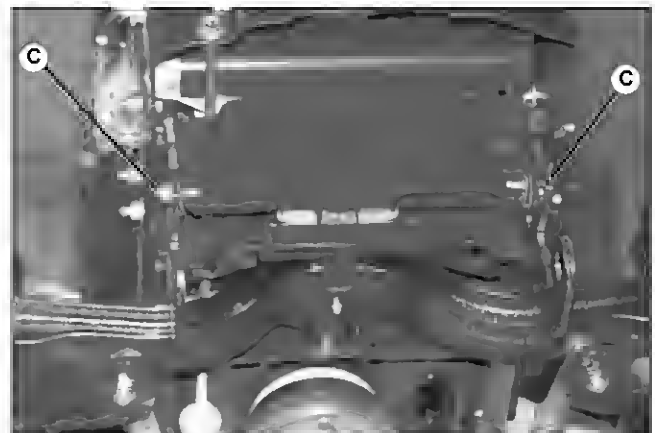
**Caution: Avoid Injury! To prevent possible burns, allow engine to cool before removing muffler**

2. Disconnect negative (-) cable from battery.



MX37059

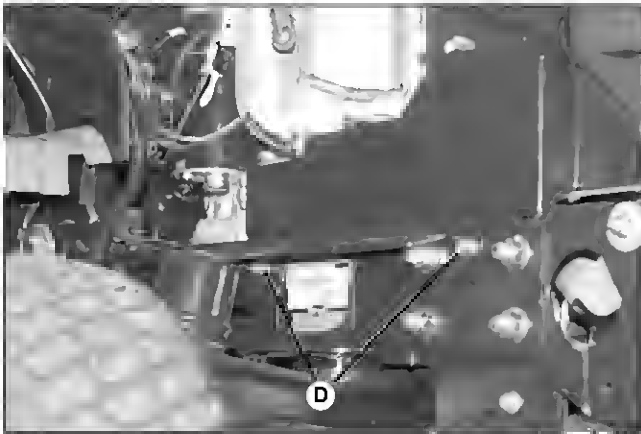
3. Remove six screws (B) securing top heat shield (A) to frame.



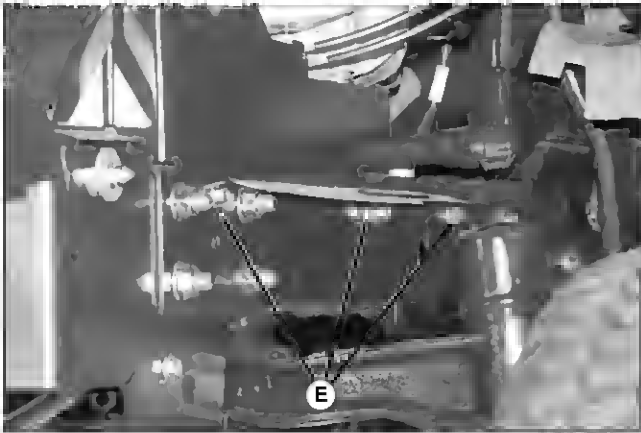
MX37062

4. Remove two screws (C) securing lower heat shield to frame.

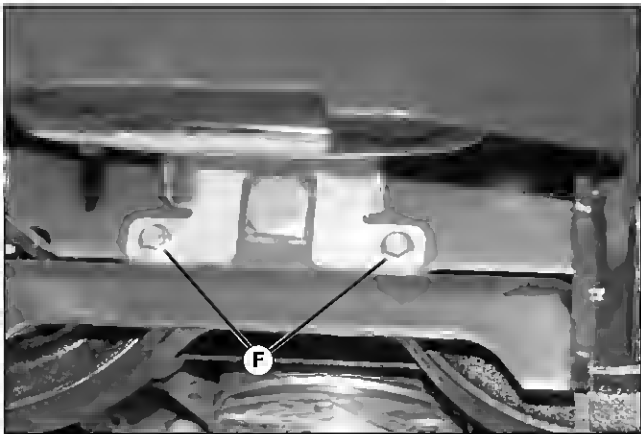
## ENGINE - KAWASAKI (FH491V) REPAIR



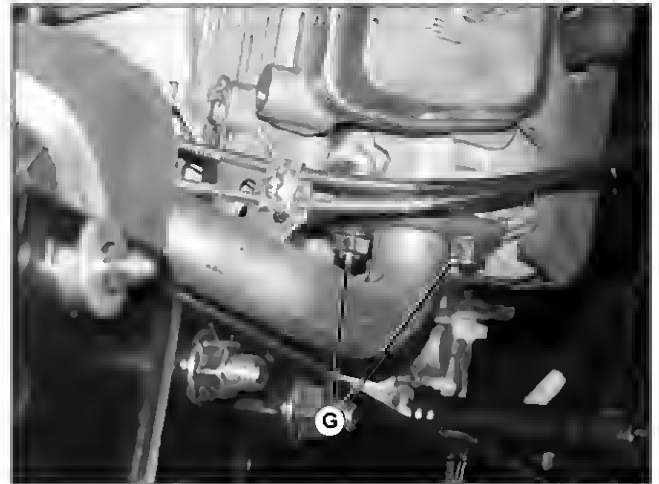
5. Remove two screws (D) securing right side heat shield to frame.



6. Remove three screws (E) securing left side heat shield to frame.



7. Remove two screws (F) securing muffler mounting bracket to frame.



Left side shown, right side is same.

8. Remove flange nuts (G) securing exhaust pipes to engine.

9. Remove muffler and gaskets.

### Installation:

Installation is done in the reverse order of removal.

- Use new gasket for installation.

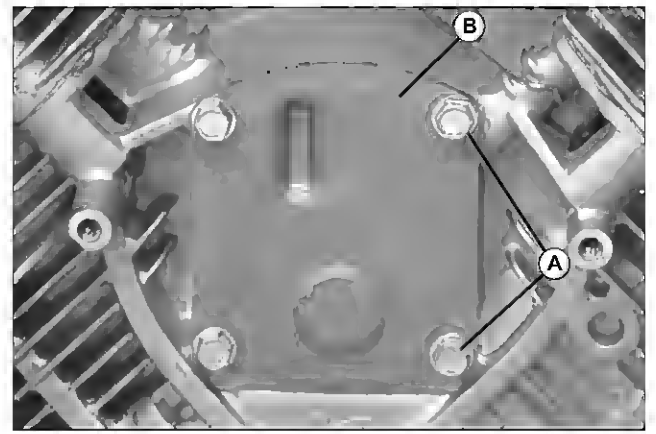
### Specifications:

Muffler Nut Torque . . . . . 6.9 N•m (61 lb-in.)

### Breather Inspection

#### Procedure:

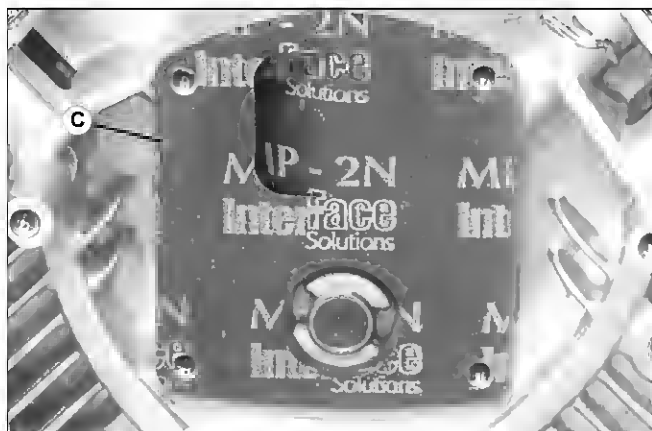
1. Remove screen and blower housing.
2. Remove stator.
3. Remove flywheel. See "Flywheel Removal and Installation" on page 58.



4. Remove four screws (A) securing the breather chamber cover to the crankcase.

# ENGINE - KAWASAKI (FH491V) REPAIR

5. Remove cover and gasket. Clean area with solvent and allow to dry.
6. Check drain hole on breather chamber to make sure no foreign material has accumulated before installing breather valve.



MX39856

7. Install a new gasket (C) so the silicone bead seal faces the crankcase.
8. Install the breather chamber cover and tighten four capscrews to **5.9 N·m (52 lb-in.)**.
9. Install stator.
10. Install flywheel. See "Flywheel Removal and Installation" on page 58.

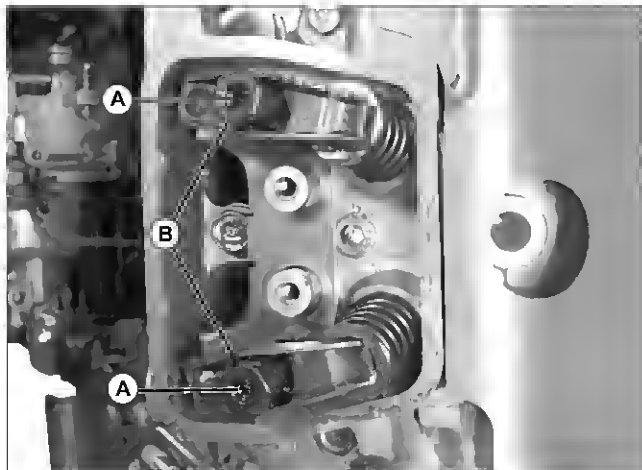
## Rocker Arm Removal and Installation

### Removal:

1. Remove spark plug and rocker arm cover.

**Note:** When piston is at top dead center (TDC) both rocker arms should not have spring tension on them.

2. Turn crankshaft until piston is at TDC of compression stroke for the cylinder being worked on.



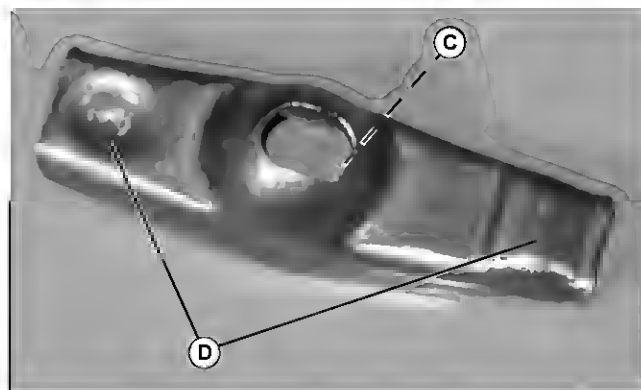
MX36440

3. Hold lock screws (A). Remove valve clearance adjustment nuts (B) and rocker arms.

**Important: Avoid Damage! Mark push rods for reassembly in original locations**

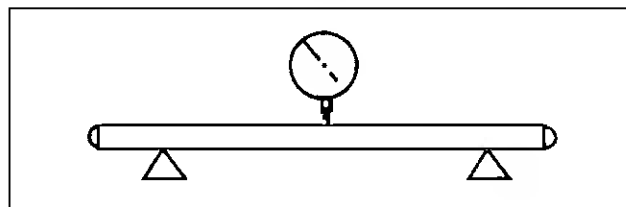
4. Inspect all parts for wear or damage. (See Inspection procedure.)

### Inspection:



MX36924

- Clean and inspect the rocker arm where it contacts the push rod and valve stem (D). Check the inside of the rocker arm where it pivots on the special nut (C). If the contact points are worn or damaged, replace the rocker arm.



M50044

- Inspect push rod for bend using V-blocks and a dial indicator. Turn rod slowly and read variation on indicator. Replace if variation is greater than **0.5 mm (0.020 in.)**.

### Installation:

Installation is done in the reverse order of removal.

**Important: Avoid Damage! Align rocker arms over push rods during assembly**

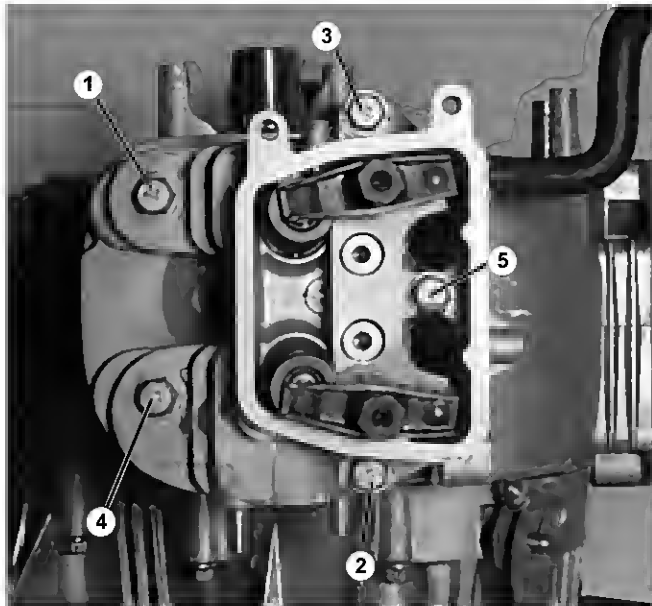
- Check and adjust valve clearance. See "Valve Clearance, Check and Adjustment" on page 47.
- Install rocker covers. Tighten rocker cover cap screws to **6.9 N·m (61 lb-in.)**.

# ENGINE - KAWASAKI (FH491V) REPAIR

## Cylinder Head Removal and Installation

### Procedure:

1. Remove the following using procedures in this section:
  - Upper blower housing.
  - Air cleaner and carburetor assemblies.
  - Muffler.
  - Intake manifold.
  - Spark plug.
2. Remove rocker cover and gasket.
3. Turn crankshaft until piston is at Top Dead Center (TDC) of compression stroke for the cylinder being worked on.



M95385

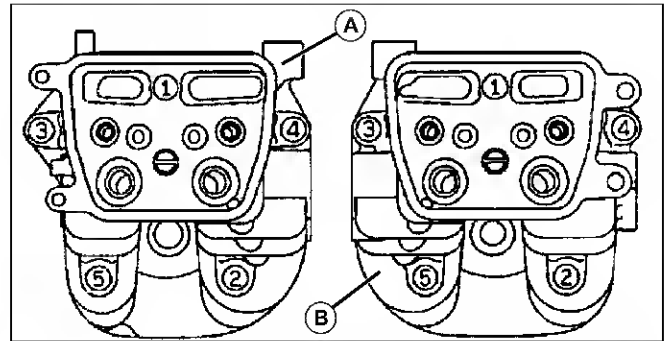
4. Loosen the cylinder head bolts 1/4 turn at a time, in sequence to prevent warping the cylinder head during removal.
5. Remove cylinder head assembly.
6. Mark push rods for installation in their original position during assembly.
7. Remove rocker arms. See "Rocker Arm Removal and Installation" on page 60.

### Installation:

**Important: Avoid Damage! Gasket surfaces are coated with sealant. Do not damage surfaces or gasket during installation.**

1. Set cylinder to TDC of compression stroke for the cylinder being worked on.
2. Set the cylinder head with gasket onto crankcase.

3. Slide the push rods into the crankcase by sliding the end of the rods down along the inside wall of the crankcase.
4. Position the push rod end on the tappet.
5. Align the upper push rod end under the rocker arms.



M95386

6. Torque should be applied in the sequence shown, in 7 N•m (62 lb-in.) increments for the number one (A) and number two (B) cylinders.

### Torque Specifications:

- First torque ..... 7 N•m (62 lb-in.)  
Second torque ..... 14 N•m (124 lb-in.)  
Third torque ..... 21 N•m (186 lb-in.)  
Final torque..... 25 N•m (221 lb-in.)

7. Install the rocker arms. See "Rocker Arm Removal and Installation" on page 60.
8. Check and adjust valve clearance. See "Valve Clearance, Check and Adjustment" on page 47.
9. Install rocker covers. Tighten rocker cover cap screws to 5.9 N•m (52 lb-in.).

## Cylinder Head Inspection

### Procedure:

1. Remove cylinder heads. See "Cylinder Head Removal and Installation" on page 61.
2. Remove carbon deposits from combustion chamber and gasket surface using SCOTCH-BRITE® abrasive pads or an equivalent.



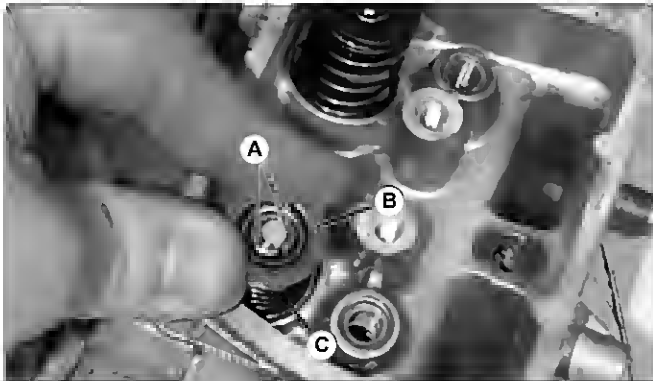
**Caution: Avoid Injury! Reduce compressed air to less than 210 kPa (30 psi) when using for cleaning purposes. Clear area of bystanders, guard against flying chips, and wear personal protection equipment including eye protection.**

3. Clean head with a suitable solvent and dry with compressed air.

# ENGINE - KAWASAKI (FH491V) REPAIR

4. Inspect for cracks or broken cooling fins.
5. Inspect gasket surface for burrs and nicks.
6. Inspect head gasket for burns and traces of gas leakage.
7. Check that oil drainback passages are not plugged.
8. Put cylinder head on a surface plate. Check for distortion at several points around the head using a feeler gauge. Replace head if distortion is more than **0.05 mm (0.002 in.)**.

## Disassembly and Assembly:



1. Compress valve spring and remove collet halves (A).
2. Remove spring retainer (B) and spring (C).

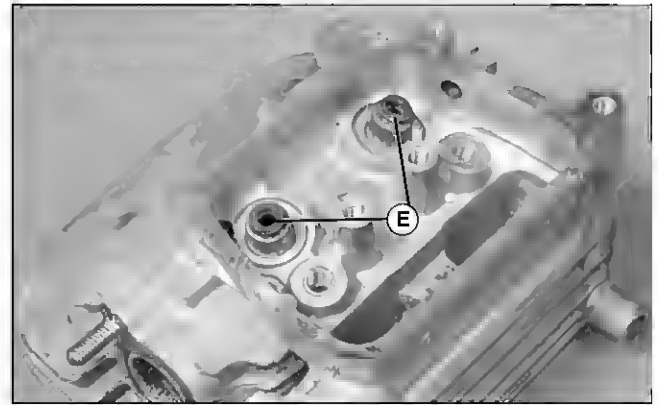


3. To replace stem seal, carefully pry up from bottom (D) with a screwdriver.
4. Inspect springs, valves, guides, and seals. (See Inspection procedure.)

Assembly is done in the reverse order of disassembly.

## Valve Guides:

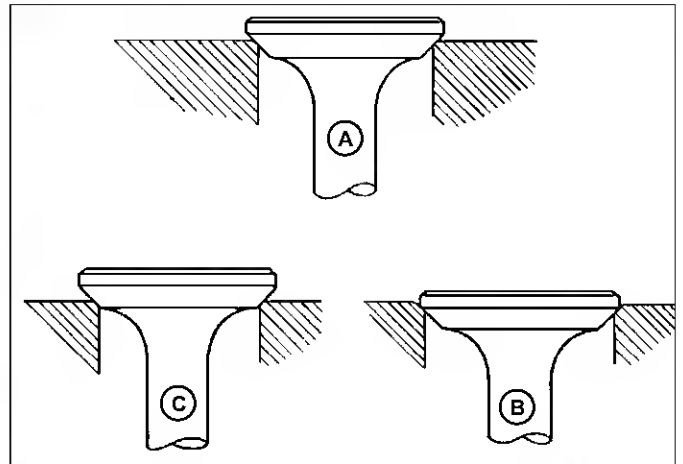
**Note:** Intake and exhaust valve guides cannot be replaced, replace head if worn.



1. Clean inside of valve guides (E) with valve guide cleaner.
2. Measure inside diameter of valve guides in several places down the length of the guide. Replace cylinder head if inside diameter is greater than **6.08 mm (0.239 in.)**.

## Valve Seats:

1. If valve seats are loose, warped or distorted beyond reconditioning, replace cylinder head. Pitted or worn seats can be re-faced using a seat cutter.

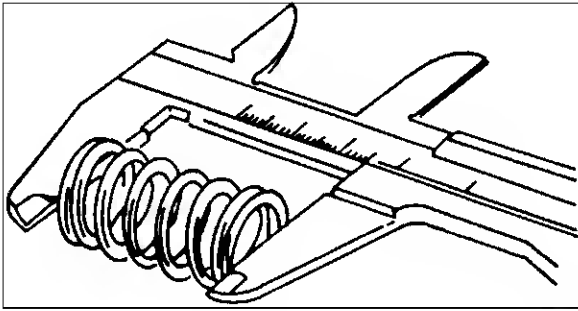


2. Check valve seating pattern for correct width and evenness all around (Note: correct seat position (A), seat too deep (B) and seat too high (C)). If valve seat width is not within **0.8 - 1.4 mm (0.03 - 0.05 in.)** intake or **1.1 - 1.6 mm (0.04 - 0.06 in.)** exhaust, recondition valve seat.
3. Lap valve after reconditioning with lapping compound and recheck valve seating surface for proper width and evenness of seating pattern. See "Lap Valves" on page 64.

## Valve Springs:

1. Inspect spring for pitting, rust, and burrs. Replace if necessary.

# ENGINE - KAWASAKI (FH491V) REPAIR

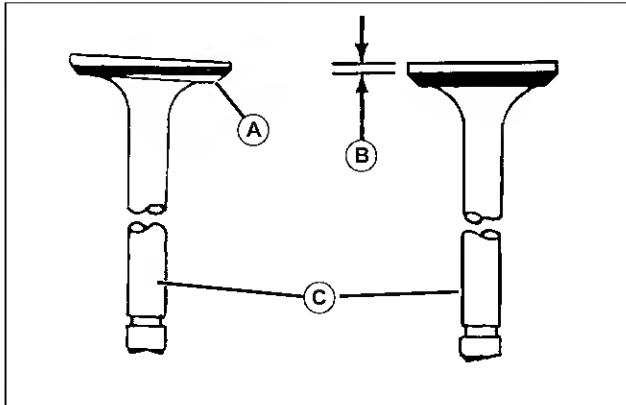


M50036

2. Measure spring free length. Replace spring if measurement is less than **31.0 mm (1.22 in.)**.

## Intake and Exhaust Valves:

1. Remove carbon from valve head, face, and stem with a power-operated wire brush. Be sure carbon is removed, not merely burnished.
2. Inspect valve head, face, and stems for defects. Replace if necessary.

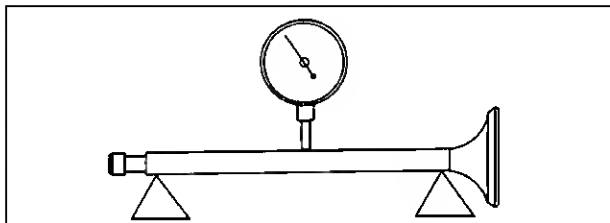


M38087

3. Replace warped valves (A) or valves with less than **0.35 mm (0.014 in.)** margin (B).
4. Measure outside diameter of valve stem (C) in several places. Replace valve if diameter is less than specification.

## Minimum Valve Stem OD Specifications:

Intake ..... **5.95 mm (0.234 in.)**  
Exhaust ..... **5.93 mm (0.233 in.)**



M51753

5. Check valve stem for bend using V-blocks and a dial indicator. Turn valve slowly and read variation on indicator.

Replace valve if variation is greater than **0.05 mm (0.002 in.)**.

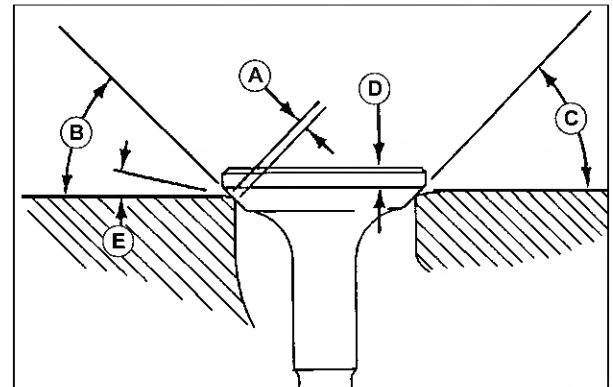
**Important: Avoid Damage! Do not grind the exhaust valve or life will be shortened.**

6. Grind the intake valve to **45°**. Replace valve if margin is less than **0.35 mm (0.014 in.)** after grinding.

## Recondition Valve Seats

### Procedure:

1. Inspect valve seats for damage. If seats are warped or distorted beyond reconditioning, replace cylinder head. Pitted or worn seats can be refaced using a seat cutter.



M9552

2. To recondition seat, cut at **45°** angle (B) to clean up seat. Cut narrowing angle (E) at **30°**. Finish cut at **45°** (B) to establish seating surface width (A).
3. Cut valve seating surface (A) as close as possible to specifications.
4. Lap valves to seats after re-facing. See "Lap Valves" on page 64.
5. Center valve seat on the valve face.
6. Check seat for good contact using Prussian Blue Compound.

### Specifications:

**A-Valve Seat Surface** .... **0.60 - 0.90 mm (0.024 - 0.035 in.)**  
**B-Valve Seat Angle** ..... **45°**  
**C-Valve Face Angle** ..... **45°**  
**D-Valve Margin (Minimum)** ..... **0.35 mm (0.014 in.)**  
**E-Valve Narrowing Angle** ..... **30°**

# ENGINE - KAWASAKI (FH491V) REPAIR

## Lap Valves

If valve seat does not make proper contact, lap the valve into the seat.

1. Apply a small amount of fine lapping compound to face of valve.

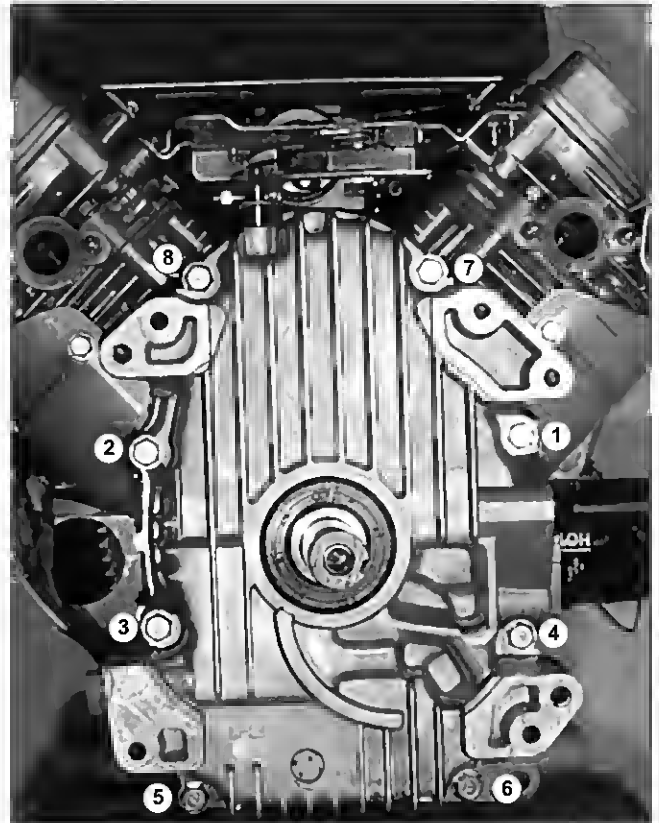


2. Grip top of valve with a vacuum cup tool and rotate valve to lap valve to seat.
3. Lift valve from seat every 8 to 10 strokes. Lap until a uniform ring appears around the surface of the valve face.
4. Wash all parts in solvent to remove lapping compound. Dry all parts.
5. Check position of lap mark on valve face. Lap mark must be on or near center of valve face.

## Crankcase Cover Removal and Installation

1. Drain crankcase. Capacity (with filter) is approximately 1.7 L (1.8 qt).
2. Remove crankcase cover and gasket.
3. Clean crankcase and crankcase cover gasket surfaces.

**Note: Do not force cover. Gears must mesh for proper positioning.**



4. Install gasket and cover. Tighten cap screws in a two step process to specification. Use the sequence shown above.

### Torque Specifications:

Initial Torque..... 10 N•m (88 lb-in.)  
Final Torque ..... 25 N•m (221 lb-in.)

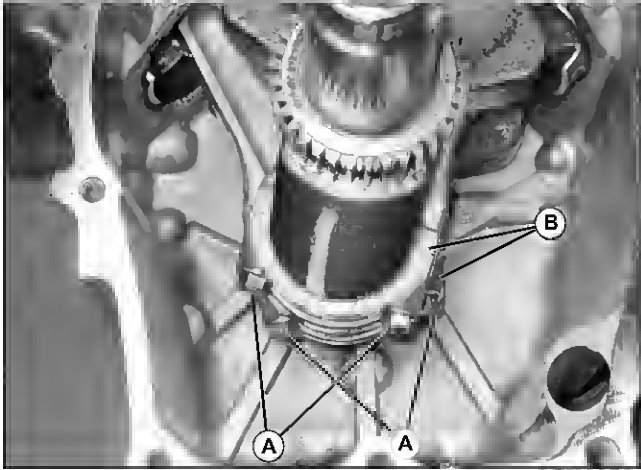


# ENGINE - KAWASAKI (FH491V) REPAIR

## Piston and Connecting Rod

### Removal:

1. Remove cylinder head.
2. Remove the crankcase cover.
3. Remove the camshaft.
4. Turn the crankshaft to expose the connecting rod cap screws.



MX36930

5. Remove the cap screws (A) and take off the connecting rod caps (B). Note the position of the connecting rod caps for reinstallation.
6. Check cylinder bore for carbon and varnish ridges. These ridges can cause piston damage if not removed.
7. If necessary, remove ridges from top of cylinder bore with a ridge reamer.
8. Push piston and connecting rod up into the cylinder and pull out of the cylinder bore.

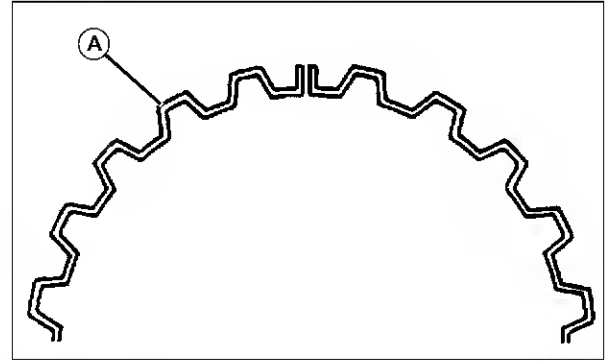
### Disassembly:

- Remove piston rings with a piston ring expander.
- Inspect all parts for wear or damage. Replace as necessary.

**Note:** Location of the arrow match mark on the piston head in relation to "K" mark on the connecting rod. Keep parts together as a set.

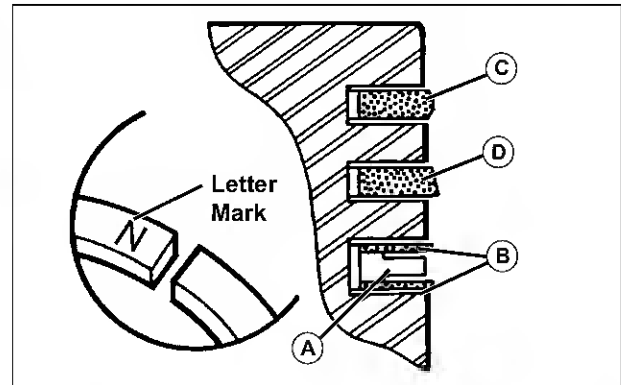
1. Remove one of the piston pin snap rings with a needle nose pliers.
2. Remove the piston pin by pushing it out of the side of the piston that has the ring removed.
3. Using a piston ring pliers, remove the top and second rings.
4. Remove the three piece oil ring.

### Assembly:

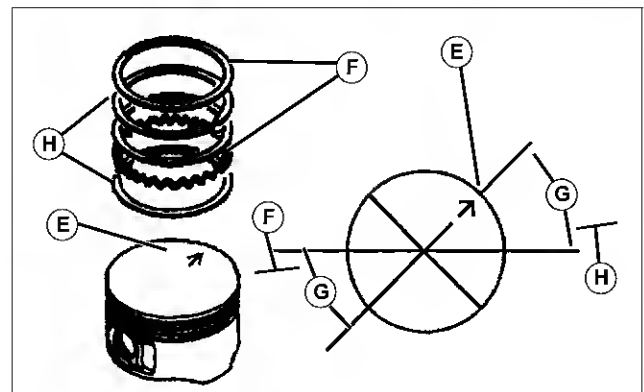


M95389

1. Install the expander (A) in the piston oil ring groove so that the expander ends touch together. Be sure that they do not overlap.
2. Install the upper and lower steel oil rails. There is no up or down to the rails. They can be installed either way.

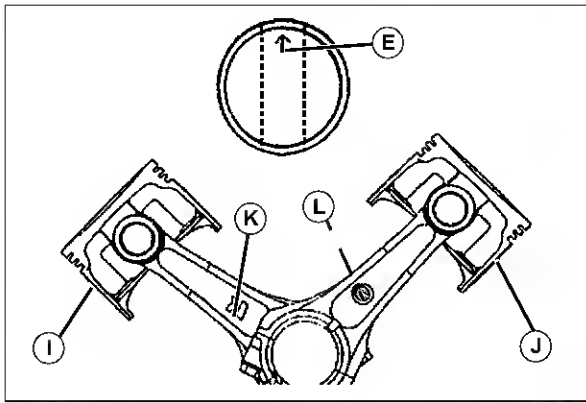


M38074A



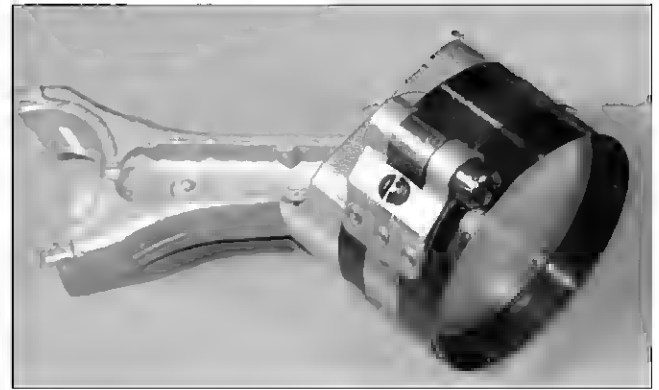
M95393

# ENGINE - KAWASAKI (FH491V) REPAIR



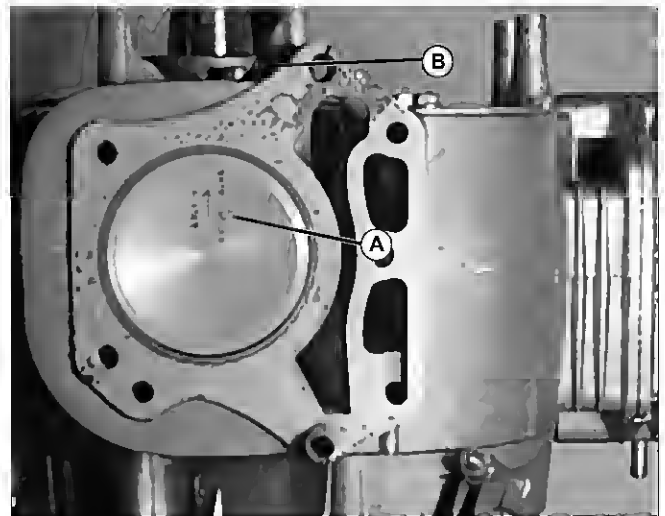
M95392

- A- Expander
- B- Steel Oil Rails
- C- First Compression Ring - Chrome-Plated
- D- Second Compression Ring
- E- Arrow Match Mark
- F- Top Ring End Gap / Upper Steel Rail End Gap
- G- 30° - 45°
- H- Second Ring End Gap / Lower Steel Rail End Gap
- I- No. 1 Cylinder Piston
- J- No. 2 Cylinder Piston
- K- "K" Mark
- L- "K" Mark On Opposite Side



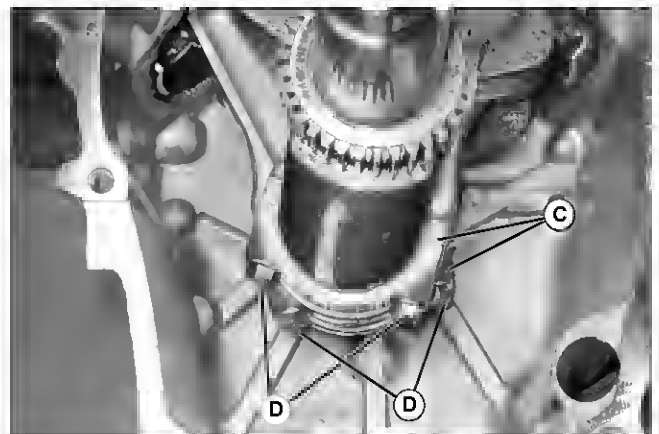
MX36931

2. Apply a light film of oil to piston and rings. Compress rings with a ring compressor.



M95391

3. Install piston assembly in cylinder bore with engraved match mark/arrow (A) on piston head facing flywheel side (B) of engine.



MX36930

4. Install connecting rod caps (C) and cap screws (D) in their original positions. Tighten cap screws to **5.9 N•m (52 lb-in.)**.

3. Install the chrome-plated top ring and second ring with "N" mark facing up. The rings should turn freely in the grooves.

4. Align the piston and rings with the piston ring end gap as shown above.

5. Apply a light film of clean engine oil to piston pin and connecting rod bearing during assembly.

6. No. 1 cylinder piston:  
Align the arrow match mark on the piston head opposite the raised letter "K" mark on the connecting rod.

7. No. 2 cylinder piston:  
Align the arrow match mark on the piston head with the raised letter "K" mark on the connecting rod.

8. Install piston pin and snap ring. Compress snap ring only enough to install the snap ring.

9. Fit a new piston pin snap ring into the side of the piston so that the ring opening of the snap ring does not coincide with the notch in the edge of the piston pin hole.

## Installation:

1. Deglaze cylinder bore.

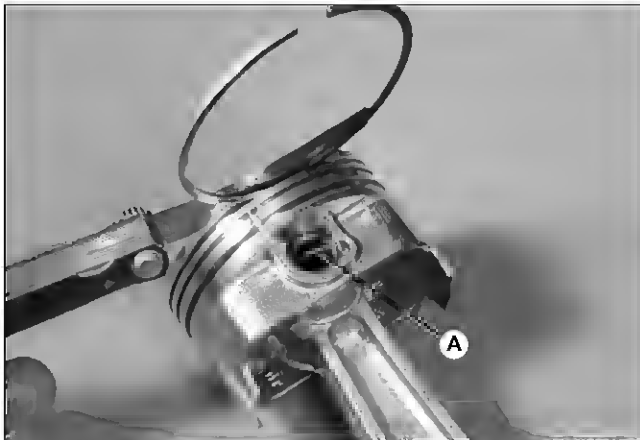
# ENGINE - KAWASAKI (FH491V) REPAIR

5. Install crankcase cover and cylinder head.

## Piston Inspection:

**Important: Avoid Damage! Do not use a caustic cleaning solution or a wire brush to clean piston.**

1. Remove all deposits from the piston.
2. Clean carbon from piston ring grooves with a ring groove cleaner. If cleaning tool is not available, break an old ring and use it to carefully clean groove.
3. Check that oil return passages in grooves are open.
4. Inspect piston for scoring or fractures. Replace piston if damaged.



MX36933

5. Check ring grooves for wear at several points around piston. Replace piston if clearance is greater than specifications.

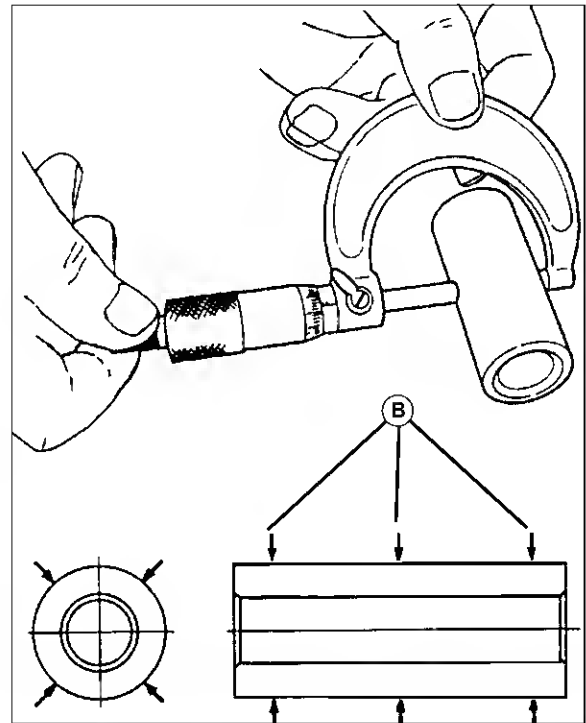
## Ring Groove Side Clearance Specifications:

**1st Compression Ring (Top) . . . . . 0.15 mm (0.006 in.)**

**2nd Compression Ring (Middle) . . . 0.12 mm (0.005 in.)**

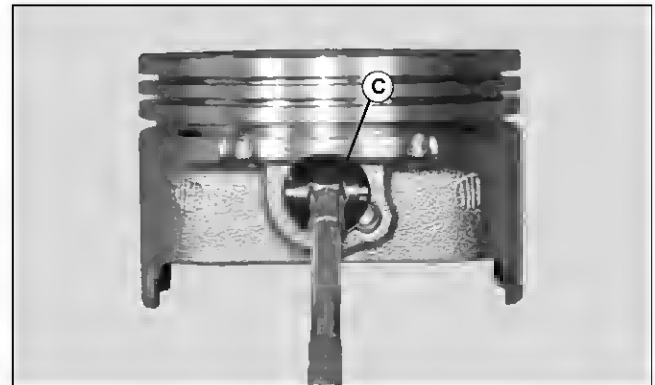
**Oil Ring . . . . . Visually Check**

6. The oil ring is a three piece assembled ring. It is difficult to measure the ring groove clearance and thickness. Visually inspect only.
7. Remove the spring clip (A) and piston pin to remove piston from connecting rod.



M82050A

8. Measure piston pin diameter at six places (B). Replace pin if measurement is less than **15.96 mm (0.628 in.)**.

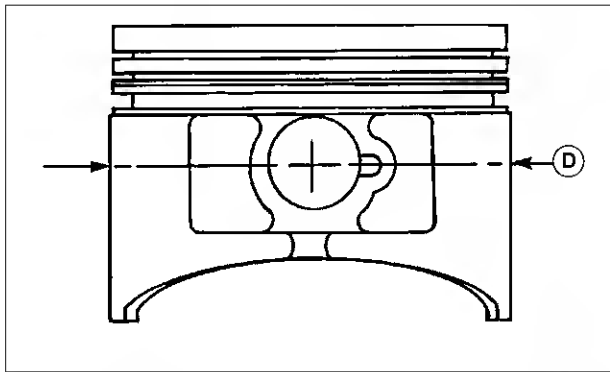


MX36934

9. Measure piston pin bore (C). Replace piston if measurement is greater than **16.08 mm (0.633 in.)**.

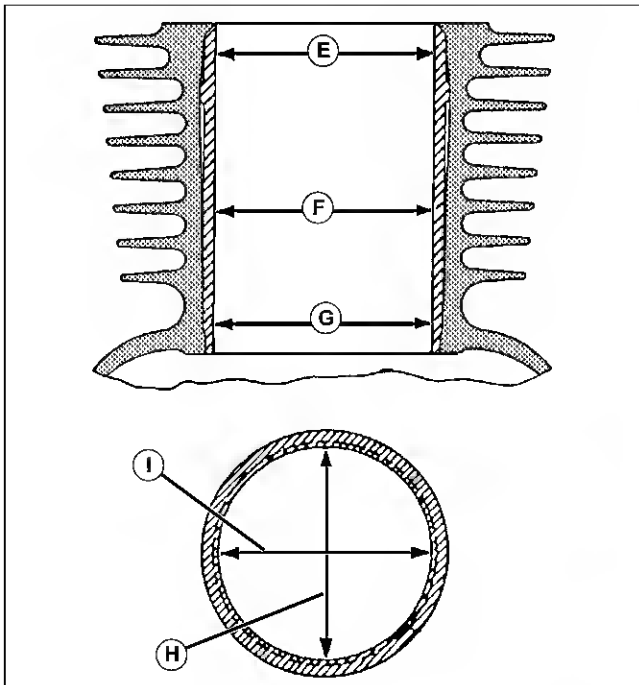
**Note: If the engine has had a previous major overhaul, oversize piston and rings may have been installed. Piston and rings are available in 0.50 mm (0.020 in.) oversize.**

# ENGINE - KAWASAKI (FH491V) REPAIR



M80398

10. Measure piston OD (D) perpendicular to piston pin bore. If piston diameter is less than specifications, install a new piston.



M82411A

11. Measure cylinder bore diameter at three positions; top (E), middle (F) and bottom (G). At these three positions, measure, in both directions; along crankshaft centerline (H) and direction of crankshaft rotation (I).

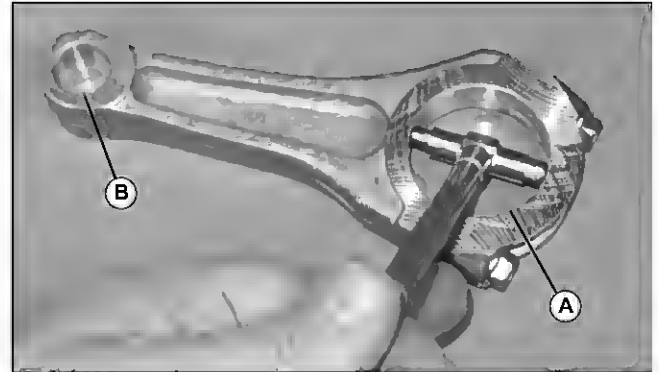
**Note: If the engine has had a previous major overhaul, oversize piston and rings may have been installed. Pistons and rings are available in 0.50 mm (0.020 in.) oversize.**

12. If cylinder bore exceeds wear limit, rebore cylinder or replace cylinder block. See "Resize Cylinder Bore" on page 72.

**Note: If cylinder is rebored, oversize piston and rings must be installed.**

## Connecting Rod:

1. Analyze crankshaft and connecting rod wear.
2. Clean and inspect rod. Replace if scored.
3. Install connecting rod cap. Tighten to **5.9 N•m (52 lb-in.)**.

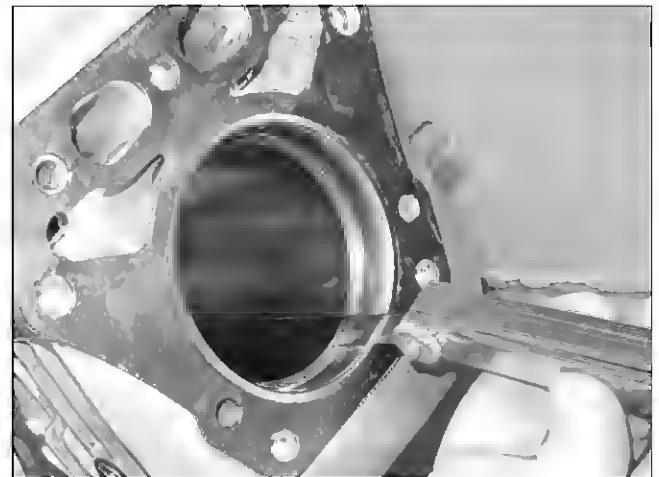


MX36935

4. Measure connecting rod crankshaft bearing diameter (A) and piston pin diameter (B). Replace connecting rod if either measurement is greater than specifications.

## Piston Rings:

1. Measure thickness of top and second piston rings at several places. If thickness is less than **1.40 mm (0.055 in.)**, replace piston ring.



MX36936

2. Check piston ring end gap. Install each ring squarely in bore approximately **25.4 mm (1.0 in.)** down from top of cylinder.
3. Check end gap. Replace if end gap is greater than specifications.

## Ring Groove Side Clearance Specifications:

- |   |                     |
|---|---------------------|
| 1st Compression Ring . . . . .          | 0.15 mm (0.006 in.) |
| 2nd Compression Ring . . . . .          | 0.12 mm (0.005 in.) |
| Oil Control Ring (Side Rails) . . . . . | 1.05 mm (0.041 in.) |

# ENGINE - KAWASAKI (FH491V) REPAIR

## Piston OD Specifications:

Standard Piston .....	67.79 mm (2.669 in.)
Oversized Piston .....	68.29 mm (2.689 in.)

## Cylinder Bore ID:

Standard Bore .....	67.98 - 68.00 mm (2.676 - 2.677 in.)
Oversized Bore .....	68.48 - 68.50 mm (2.696 - 2.697 in.)
Bore Out of Round .....	0.01 mm (0.0004 in.)
Bore Out of Round Limit .....	0.06 mm (0.002 in.)

## Connecting Rod Bearing ID (Wear Limit):

Crankshaft Bearing .....	35.06 mm (1.380 in.)
Piston Pin Bearing .....	16.05 mm (0.633 in.)

## End Gap Specifications:

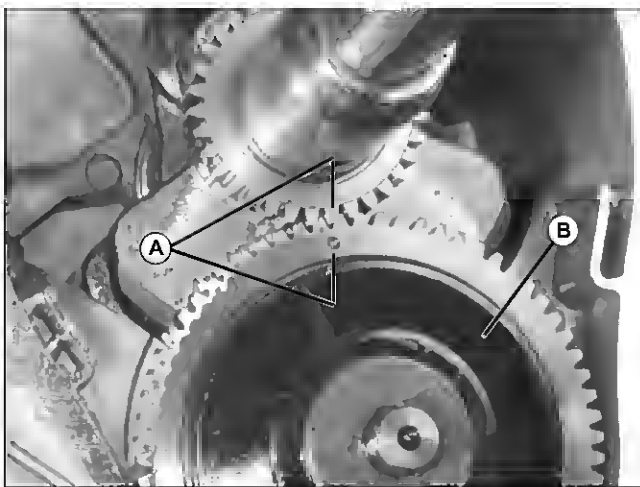
Top Ring .....	0.70 mm (0.028 in.)
Second Ring .....	0.78 mm (0.031 in.)
Oil Control Ring .....	1.05 mm (0.041 in.)

## Camshaft and Tappets

### Removal and Installation:

1. Remove fuel pump.
2. Remove rocker arm assemblies.
3. Remove crankcase cover.

**Important: Avoid Damage! Align timing marks to prevent damage to tappets when removing camshaft.**

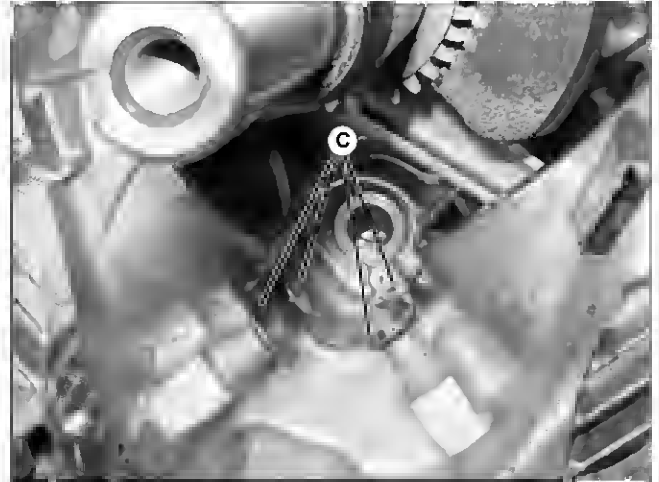


MX36937

4. Rotate crankshaft until timing marks (A) align.
5. Remove and inspect camshaft (B).

**Note: Mark tappets so they can be installed in their**

*original guides during assembly.*



MX37384

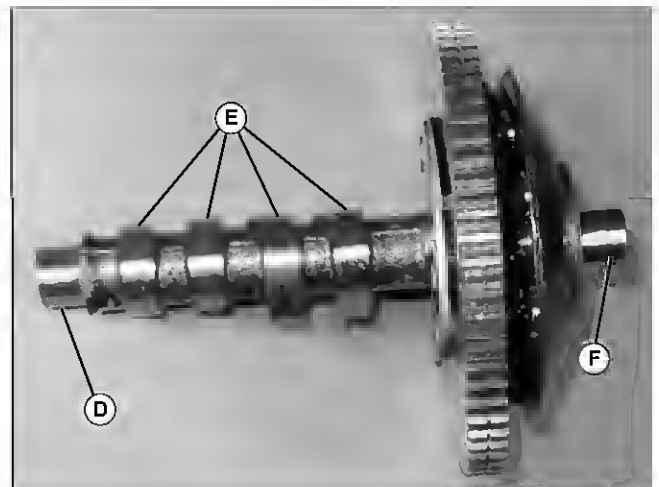
6. Remove and inspect tappets (C) for wear or damage. Replace if necessary.

**Installation is done in the reverse order of removal.**

- Align timing marks when installing camshaft.

### Inspection:

1. Inspect camshaft for worn or broken teeth.



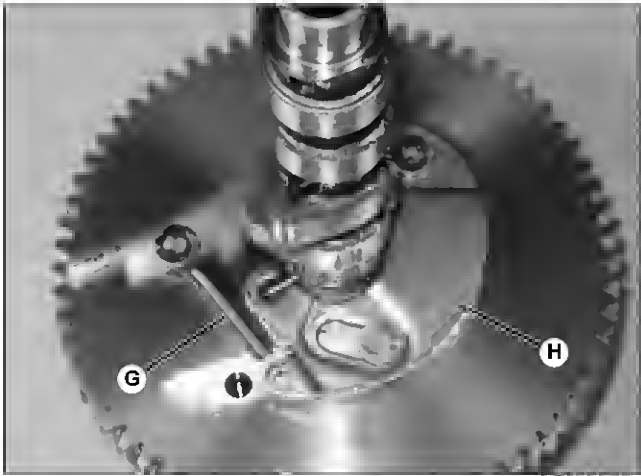
MX37371

2. Measure PTO side journal (F), flywheel side journal (D) and lobes (E). Replace camshaft and tappets if any measurement is less than specifications.

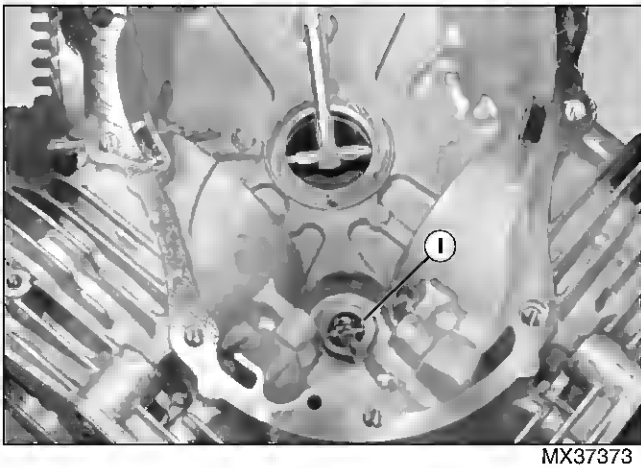
### Camshaft Specifications (Minimum):

Side Journals .....	15.98 mm (0.629 in.)
Cam Lobe Height .....	29.62 mm (1.166 in.)

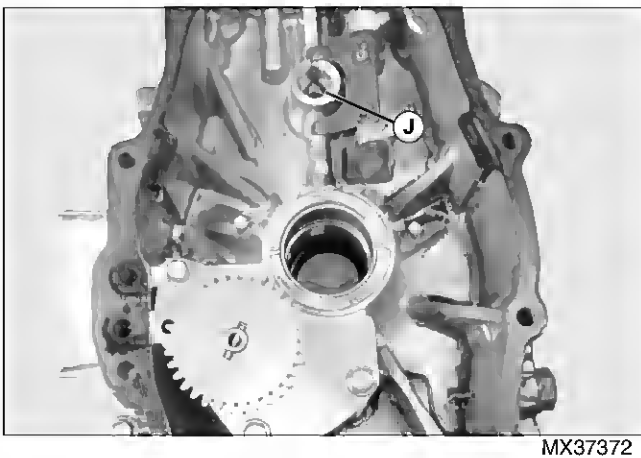
# ENGINE - KAWASAKI (FH491V) REPAIR



3. Inspect Automatic Compression Release weight (H) for damage.
4. Inspect spring (G). Replace if worn or damaged.
5. Shake the camshaft assembly and check that the ACR weight (H) swings smoothly.



**Picture Note: Cylinder Block Bearing**



**Picture Note: Crankcase Cover Bearing**

6. Measure camshaft bearings in cylinder block (I) and crankcase cover (J). Replace block or cover if either diameter is greater than 16.13 mm (0.635 in.).

## Camshaft Specifications (Minimum):

Side Journals	15.98 mm (0.629 in.)
Cam Lobe Height	29.13 mm (1.147 in.)

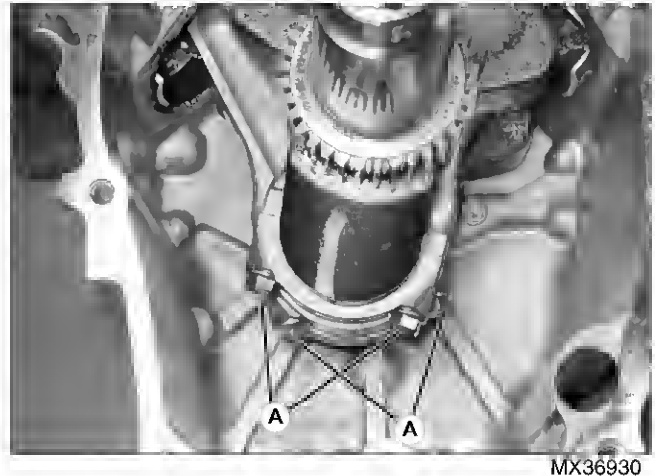
## Crankshaft and Main Bearings

### Removal and Installation:

1. Remove flywheel and crankcase cover.
2. Remove camshaft.

**Important: Avoid Damage! Connecting rod caps must be installed on the same connecting rods they were removed from.**

3. Mark connecting rod caps to aid in installation.



4. Remove connecting rod caps (A) and push pistons to top of cylinder.
5. Remove crankshaft.
6. Inspect crankshaft for wear or damage.

### Installation is done in the reverse order of removal.

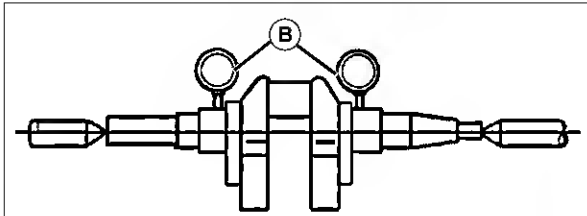
- Cover keyway on flywheel end of crankshaft with tape to prevent seal damage when installing crankshaft.
- Apply a light film of clean engine oil on crankshaft bearing surfaces before installation.
- Pack oil seals with lithium base grease.
- Install connecting rod caps and tighten to 5.9 N•m (52 lb-in.).

# ENGINE - KAWASAKI (FH491V) REPAIR

## Inspection:

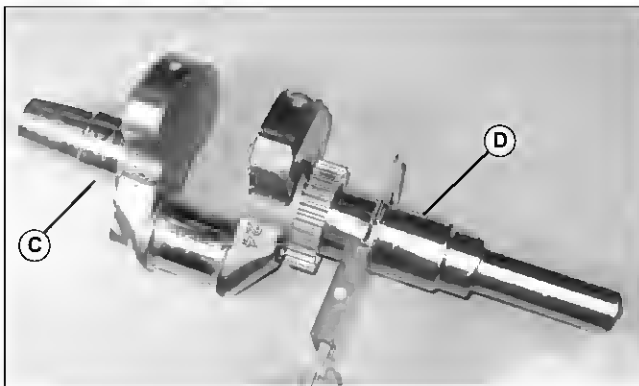
**Important: Avoid Damage! A bent crankshaft must be replaced; it cannot be straightened.**

1. Place crankshaft into an alignment jig and slowly rotate crankshaft. Use dial indicators (B) to measure maximum Total Indicated Runout (TIR). If runout exceeds **0.05 mm (0.002 in.)**, replace crankshaft.



M80432

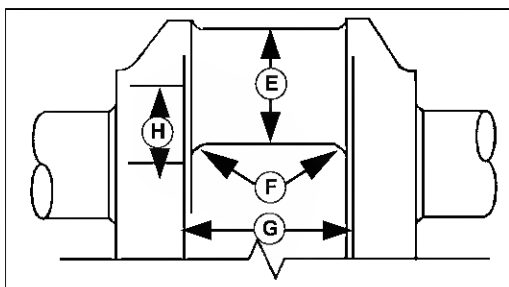
2. Place crankshaft into an alignment jig and slowly rotate crankshaft. Use dial indicators (B) to measure maximum Total Indicated Runout (TIR). If runout exceeds **0.05 mm (0.002 in.)**, replace crankshaft.



MX37374

3. Measure main bearing journal diameters. If PTO side journal (D) OD is less than **34.90 mm (1.374 in.)** replace crankshaft. If flywheel side journal (C) OD is less than **34.93 mm (1.375 in.)** replace crankshaft.

**Note: If the engine has had a previous overhaul, connecting rod journal may have been resized for undersized rod. A 0.50 mm (0.020 in.) undersized rod is available.**

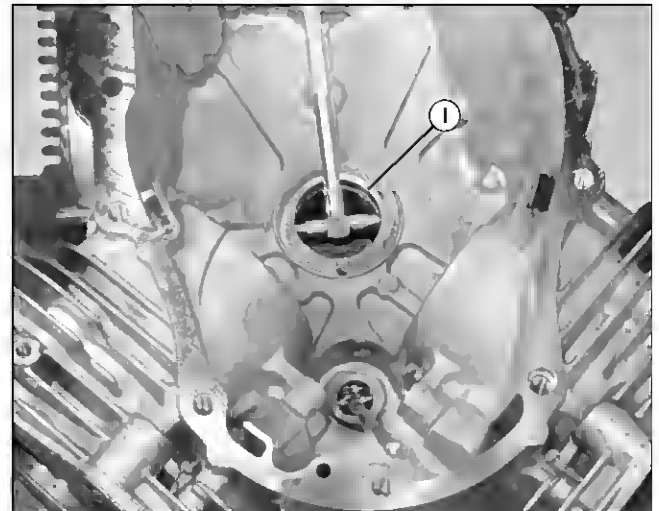


M57348

4. Measure connecting rod journal diameter (E) and

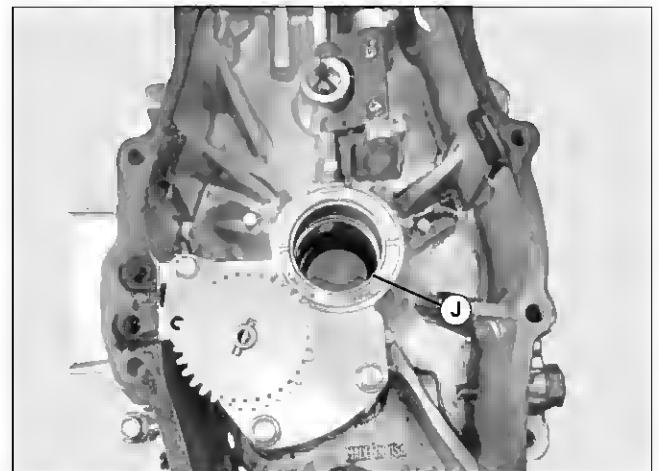
inspect journal radii (F) for cracks. Connecting rod journal can be resized to accept undersized rod. Have grinding done by a reliable repair shop.

If undersized journal diameter is less than specifications, replace crankshaft.



MX37373

**Picture Note: Cylinder Block Bearing**



MX37372

**Picture Note: Crankcase Cover Bearing**

5. Measure crankshaft main bearing diameter in crankcase (I) and crankcase cover (J). Replace crankcase cover or crankcase if diameter is greater than **35.15 mm (1.384 in.)**.

## Connecting Rod Journal OD (Wear Limit):

Standard ..... **34.93 mm (1.375 in.)**

## Resizing Specifications:

**E- Connecting Rod Journal 34.470 - 34.457 mm (1.357 - 1.356 in.)**

**G- Maximum ..... 39.40 mm (1.551 in.)**

**H- Maximum ..... 34.05 - 33.95 mm (1.340 - 1.337 in.)**

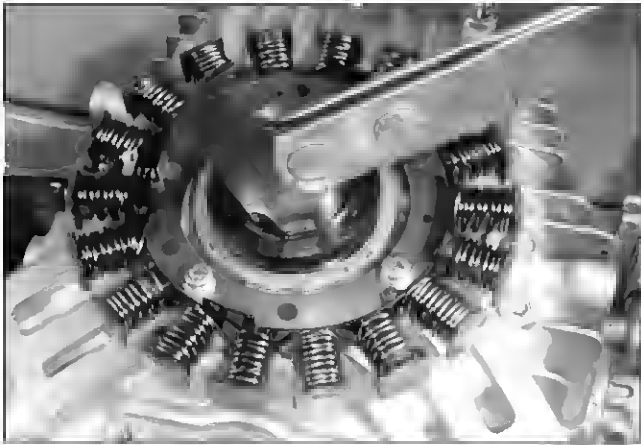
# ENGINE - KAWASAKI (FH491V) REPAIR

## Crankshaft Oil Seals

**Note:** Oil seals can be replaced with crankshaft installed. Make sure oil seal removal tool does not contact crankshaft. If engine is disassembled, simply pry out seals with a large screwdriver and install new ones with a seal driver.

### Replacement (Flywheel End):

1. Remove blower housing, fan, and flywheel.



2. Using care not to contact crankshaft or coils on stator, pry seal out of bore.
3. Apply lithium based grease inside lips of new seal. Install seal with lip toward inside of engine. Using a seal driver, install seal flush with top of bore.

### Replacement (PTO End):

1. PTO End: Remove clutch and sheave assemblies. Remove engine from machine.



2. Using care not to contact crankshaft, pry seal out of crankcase cover
3. Apply lithium based grease inside lips of new seal.
4. Install seal with lip toward inside of engine using a seal driver. Press in seals until flush with flange surface.

## Deglaze Cylinder Bore

1. Deglaze cylinder bore using a rigid hone with a 220 to 300 grit stone.
2. Use hone as instructed by manufacturer to obtain 45° crosshatch pattern.

**Important: Avoid Damage! Do not use gasoline, kerosene, or commercial solvent to clean cylinder bores. Solvents will not remove all abrasives from cylinder walls.**

3. Clean cylinder walls using clean white rags and warm soapy water. Continue to clean cylinder until white rags show no discoloration.

## Resize Cylinder Bore

### Procedure:

**Important: Avoid Damage! Check stone for wear or damage. Use correct stone for the job.**

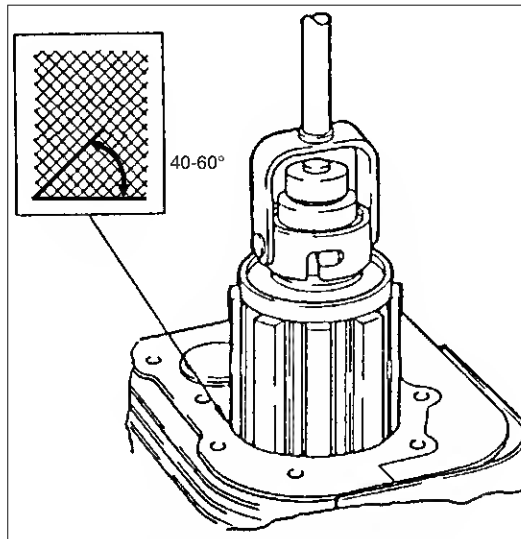
The cylinder block can be resized to use **0.50 mm (0.020 in.)** oversize pistons and rings. Have a reliable repair shop resize the block, or use the drill press and honing tool. Resize cylinder with a honing tool to initial and final bore specifications.

1. Align center of bore to drill press center.
2. Lower and raise hone until ends extend **20 - 25 mm (0.75 - 1.0 in.)** past ends of cylinder.
3. Adjust hone so lower end is even with end of cylinder bore.
4. Adjust rigid hone stones until they contact narrowest point of cylinder.
5. Coat inside of cylinder with honing oil. Turn hone by hand. Adjust if too tight.
6. Run drill press between 200 - 250 rpm. Move hone up and down in cylinder approximately 20 times per minute.

**Note: Measure bore when cylinder is cool.**



# ENGINE - KAWASAKI (FH491V) REPAIR



7. Stop press and check cylinder diameter.

**Note:** *Finish should not be smooth, but have a 40 - 60° cross-hatch pattern.*

8. Check bore for size, taper, and out-of-round.

9. Hone the cylinder an additional **0.006 - 0.008 mm (0.0002 - 0.0003 in.)** for final bore specifications. This allows for shrinkage when cylinder cools.

**Important: Avoid Damage! DO NOT use gasoline or commercial solvents to clean cylinder bores. Solvents will not remove metal particles produced during honing**

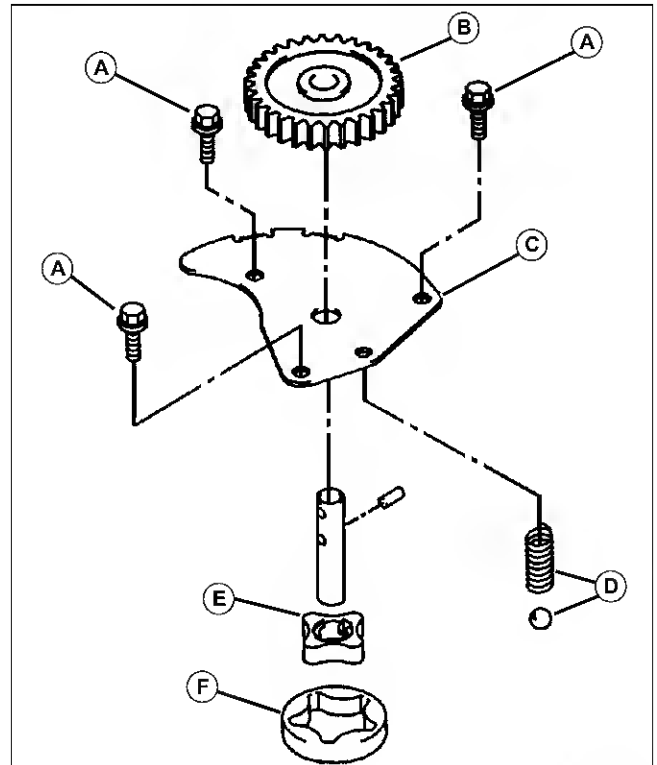
10. Clean the cylinder thoroughly using soap, warm water and clean rags. Continue to clean cylinder until white rags show no discoloration.

11. Dry the cylinder. Apply engine oil to cylinder wall.

## Oil Pump Disassembly and Assembly

### Disassembly:

1. Remove crankcase cover. See "Crankcase Cover Removal and Installation" on page 64.



2. Remove the three mounting cap screws (A) and lift the oil pump gear and shaft assembly (B) and cover plate (C) out of the crankcase.

3. Remove relief valve spring and ball (D).

4. Remove the inner (E) and outer (F) rotors.

5. Inspect all parts for wear or damage.

### Assembly is done in the reverse order of disassembly.

1. Fill rotor housing with engine oil for initial lubrication.

2. Install the outer (F) and inner (E) rotors.

3. Install relief valve ball and spring (D).

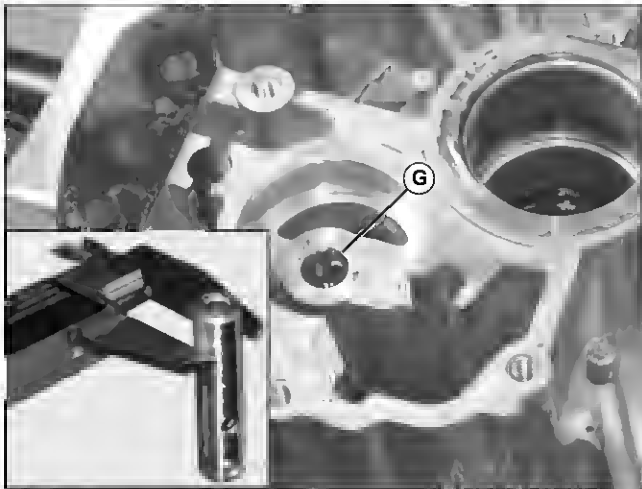
4. Install oil pump gear and shaft assembly (B), cover plate (C), and secure with three cap screws (A).

5. Tighten the three cap screws (A) to **6.9 N•m (61 lb-in.)**.

# ENGINE - KAWASAKI (FH491V) REPAIR

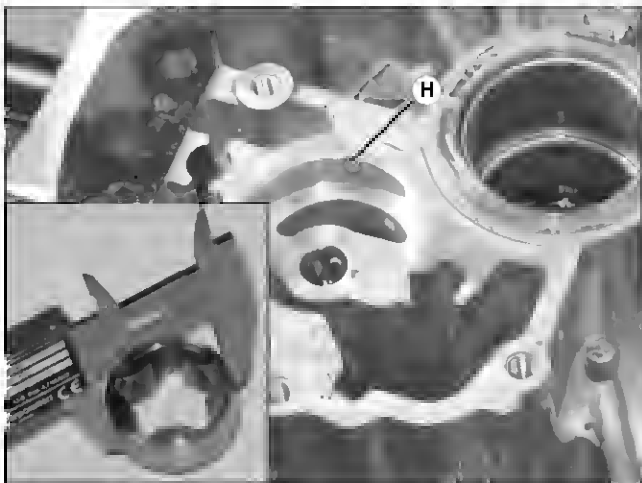
## Inspection:

Inspect all parts for wear or damage. Replace as necessary.



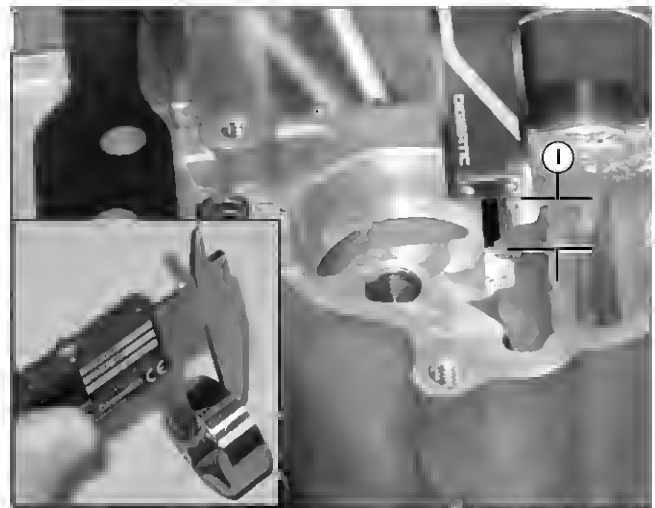
MX37378, MX37377

1. Measure rotor shaft diameter. If shaft OD is less than **10.92 mm (0.430 in.)**, replace shaft.
2. Measure rotor shaft bearing (G). If bearing ID is greater than **11.07 mm (0.436 in.)**, replace crankcase cover.



MX37379, MX37377

3. Measure outside diameter of outer rotor. If OD is less than **40.47 mm (1.593 in.)**, replace outer rotor.
4. Measure inside diameter of rotor housing (H). If ID is greater than **40.80 mm (1.606 in.)**, replace crankcase cover.



MX37380, MX37381

5. Measure thickness of outer rotor. If thickness is less than **9.83 mm (0.387 in.)**, replace rotor.
6. Measure outer rotor housing depth (I). If depth is greater than **10.23 mm (0.403 in.)**, replace crankcase cover.



MX37376

7. Measure inner-to-outer rotor clearance (J) with a feeler gauge. If clearance is greater than **0.2 mm (0.008 in.)**, replace both rotors.



M50083

8. Measure relief valve spring. If free length is less than **19.50 mm (0.768 in.)**, replace spring.

# ENGINE - KAWASAKI (FH491V) REPAIR

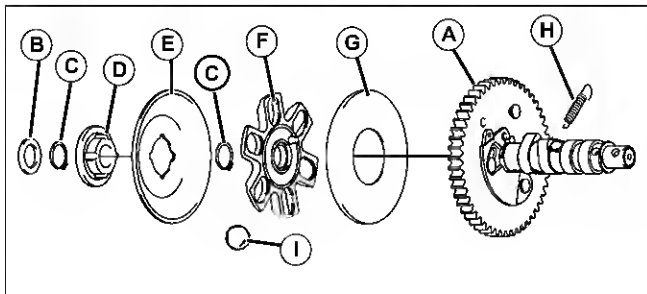
## Governor Removal, Inspection, and Replacement

1. Remove crankcase cover. See "Crankcase Cover Removal and Installation" on page 64.
2. Remove rocker covers and push rods.



MX36937

3. Turn engine upside down and remove camshaft (A).



M95423

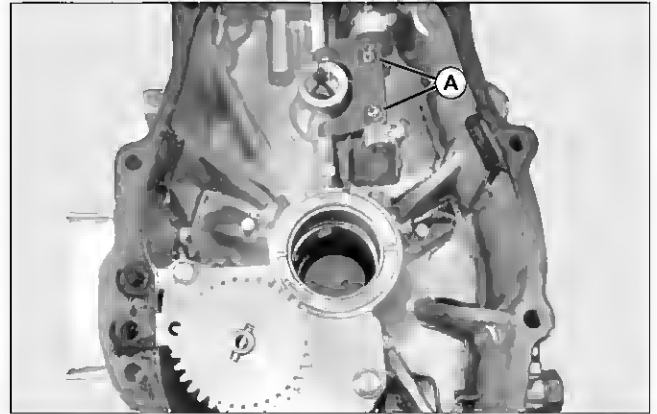
- A- Camshaft
- B- Washer
- C- Snap Ring
- D- Sleeve
- E- Governor Plate
- F- Ball Guide
- G- Ball Plate
- H- Automatic Compression Release Spring
- I- Steel Balls (6 used)

4. Disassemble the governor assembly from the camshaft.
5. Inspect governor for wear or damage. Replace if necessary.
6. When assembling, be sure the steel balls are seated in slots on the ball guide and that the snap rings are fully seated in their grooves.

## Governor Shaft Inspection and Replacement

**Note:** *It is not necessary to remove governor shaft unless damaged.*

1. Remove crankcase cover. See "Crankcase Cover Removal and Installation" on page 64.



MX37372

2. Unscrew the governor shaft plate screws (A) and pull the governor shaft out of the crankcase cover.
3. Replace the oil seal if the lip shows signs of leakage or it has been damaged.
4. Inspect governor shaft for wear or damage. Replace if necessary.

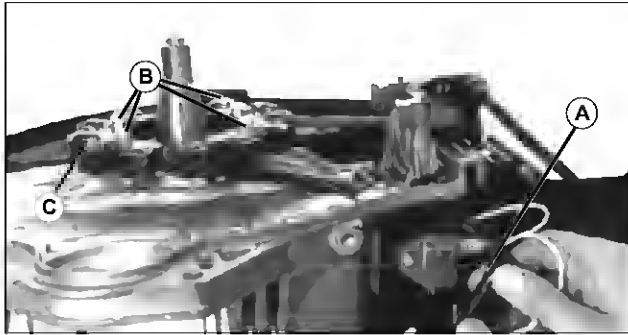
### Installation:

- Apply clean engine oil to the governor shaft.
- Insert the governor shaft into the crankcase.
- Install the governor shaft plate to the shaft and tighten the screws to **2 N•m (17 lb-in.)**.
- Check that governor shaft turns freely within its operating range.
- If oil seal has been removed, press a new seal into crankcase with the seal lip to the inside.
- Press the seal in to flush to **1.0 mm (0.04 in.)** below crankcase surface.

# ENGINE - KAWASAKI (FH491V) REPAIR

## Stator Removal and Installation

### Removal:



1. Remove flywheel.
2. Disconnect stator lead (A).
3. Remove screws (B) and stator (C).

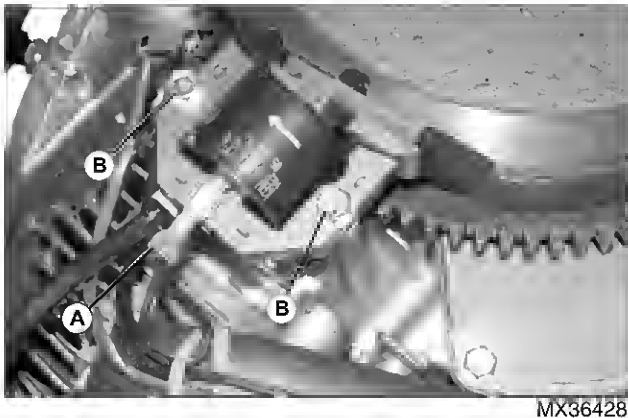
### Installation:

Installation is done in the reverse order of removal.

## Ignition Coil Removal and Installation

### Removal:

1. Remove blower housing.



2. Disconnect wire (A) from coil.
3. Remove cap screws (B) and armature with coil.
4. Replace as needed.

**Installation is done in the reverse order of removal.**

- Adjust ignition coil air gap. See "Ignition Coil Air Gap Adjustment" on page 52.

## Starting Motor

### Analyze Condition:

The starting motor overheats because of:

- Long cranking.
- Armature binding.

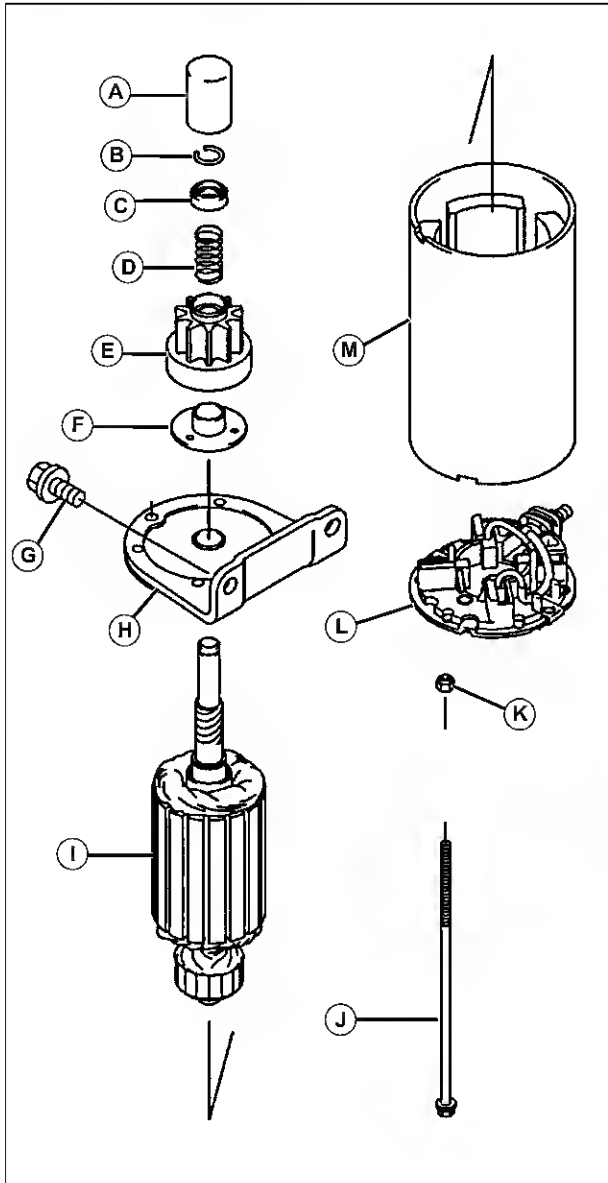
The starting motor operates poorly because of:

- Armature binding.
- Dirty or damaged starting motor drive.
- Badly worn brushes or weak brush springs.
- Excessive voltage drop in cranking system.
- Battery or wiring defective.
- Shorts, opens, or grounds in armature.

**Note: Starting motor repair is limited to brushes, end caps, and starting motor drive. Fields in starting motor are permanent magnets and are not serviceable. If housing or armature is damaged, replace starting motor.**

# ENGINE - KAWASAKI (FH491V) REPAIR

## Starter Motor Component Location



MX11600

- A- Cover
- B- C-Ring
- C- Retainer
- D- Spring
- E- Pinion
- F- Bushing
- G- Mounting Bolt
- H- End Cover
- I- Armature
- J- Thru Bolt
- K- Nut
- L- Brush Holder Assembly
- M- Housing

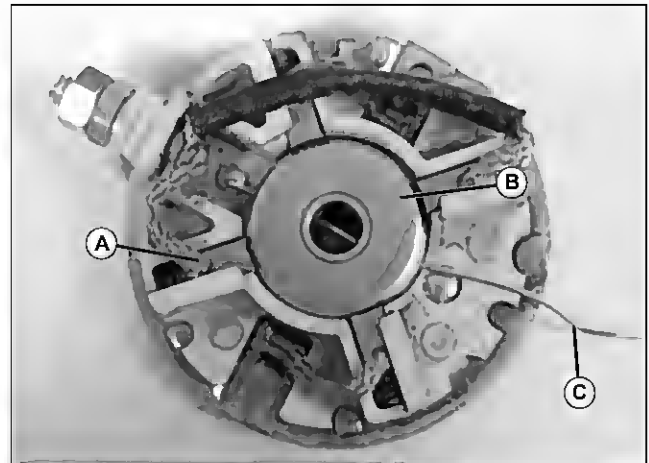
## Required Tools:

- JDG1087 C-Ring Remover
- JDG1086 C-Ring Installer

## Disassembly and Assembly:

1. Mark body and covers for correct alignment during reassembly.
2. Remove shaft cover and use a C-Ring removal tool, JDG1087 to remove the C-Ring.
3. Remove retainer (C), spring (D), pinion (E) and bushing (F).
4. Remove thru bolts (J), and cover (L) from housing (M).
5. Hold the armature (I) and the brush end cap assembly (L) against a work surface while sliding the Housing off the armature.
6. Inspect parts for wear or damage.
7. Test starting motor armature and brushes. See Inspection and Test procedures.

**Assembly is done in the reverse order of disassembly.**



MX11604

**Note:** Brush assemblies (A) can be held in the retracted position to allow installation of the end cover over the armature by using the washer (B) in the end cap to hold the brushes in the retracted position. Place a piece of wire (C) behind the washer to hold it in position, and then withdraw the wire as the assembly is lowered over the end of the armature.

Apply a lithium based lubricant sparingly to:

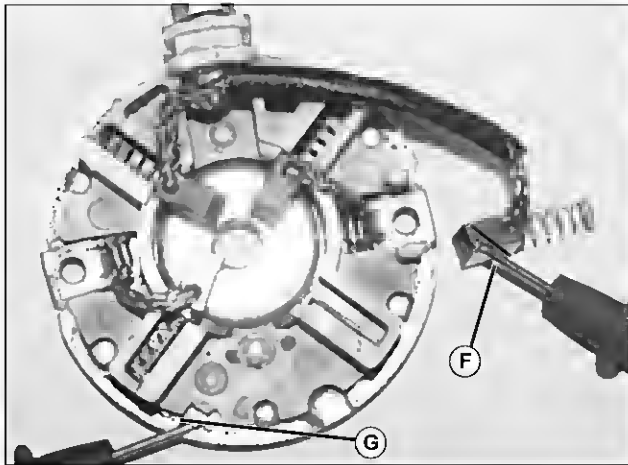
- Armature shaft splines.
- Points where shaft contacts cover.

## Inspection and Test:

1. Measure field coil brush lengths. If any one brush length is less than 10.5 mm (0.413 in.), replace all four brushes.

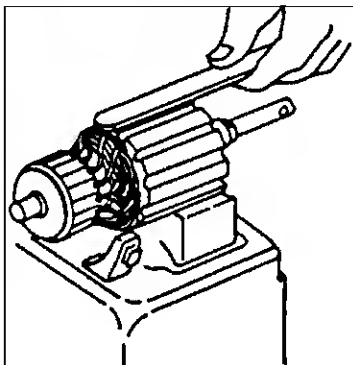
## ENGINE - KAWASAKI (FH491V) REPAIR

2. Inspect brush springs for wear or damage. Replace if necessary.



3. Test for brush continuity. Touch one probe of tester to field coil brush (F) and the other probe to the end cap housing (G). Be sure the brush lead is not touching the housing. If there is not continuity, the brush assembly must be replaced.

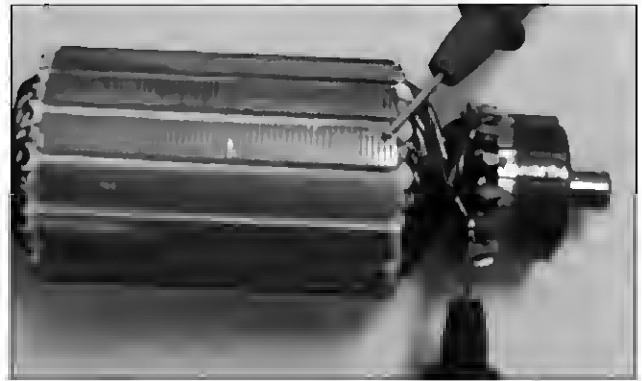
**Important: Avoid Damage! Do not clean armature with solvent. Solvent can damage insulation on windings. Use only mineral spirits and a brush.**



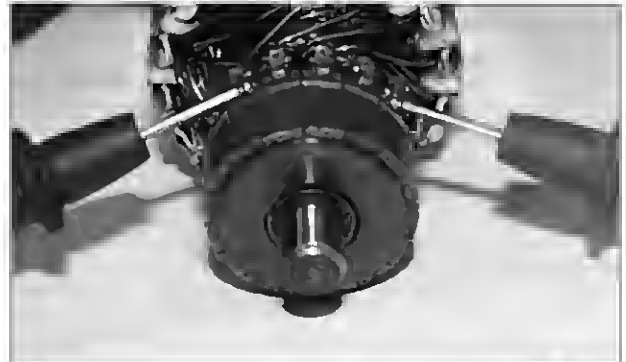
4. Locate short circuits by rotating armature on a growler while holding a hacksaw blade or steel strip on armature. The hacksaw blade will vibrate in area of short circuit.

**Note: Shorts between bars are sometimes caused by dirt or copper between bars. Inspect for this condition.**

5. If test indicates short circuited windings, clean the commutator of dust and fillings. Check armature again. If test still indicates short circuit, replace armature.



6. Test for grounded windings using an ohmmeter. Touch probes on each commutator bar. Armature windings are connected in parallel, so each commutator bar needs to be checked. If test shows continuity, a winding is grounded and the armature must be replaced.



7. Test for open circulated windings using an ohmmeter. Touch probes on each commutator bar. If test shows no continuity, there is an open circuit and armature must be replaced.

# ENGINE - KAWASAKI (FH491V) REPAIR

## No-Load Amperage Draw and RPM Test

### Reason:

To determine if starting motor is binding or has excessive amperage draw under no-load.

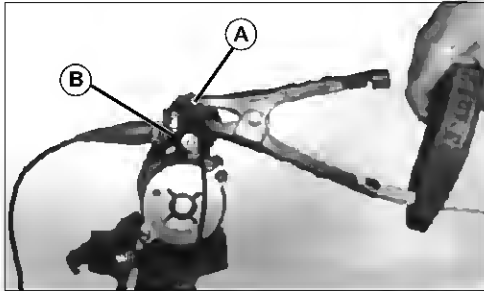
### Test Equipment:

- JT05712 Current Gun
- JT03719 Photo Tachometer

### Procedure:

**Important: Avoid Damage! Complete this test in 20 seconds or less to prevent starting motor damage.**

**Note: Check that battery is fully charged and of proper size to ensure accuracy of test.**



1. Connect jumper cables to battery.
2. Connect negative cable to starting motor body. Connect positive cable to terminal (A).
3. Use jumper wire to briefly connect terminals (A and B). Measure starting motor amperage and rpm. Maximum starting motor amperage is 50 amps at 5000 rpm.

### Results:

- If amperage is out of specification, check for binding or seizing bearings, sticking brushes, dirty or worn commutator. Repair or replace starting motor.

## Starting Solenoid Test

### Reason:

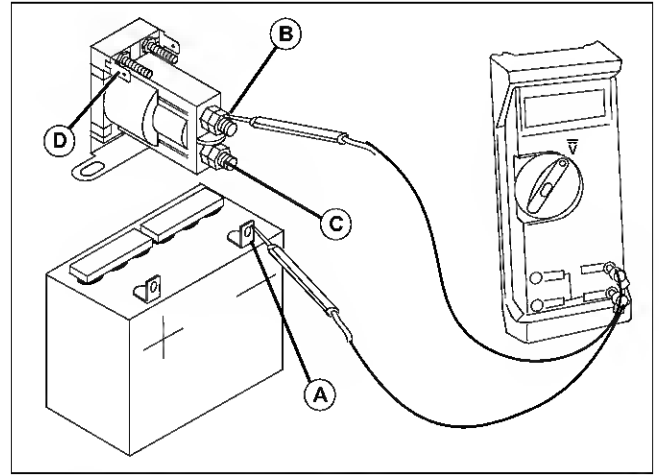
To determine if starting solenoid is defective.

### Test Equipment:

- Volt Ohm Meter

### Procedure:

**Note: Check that battery is fully charged and of proper size to ensure accuracy of test.**



1. Park machine safely on level surface. See "Park Machine Safely" in the Safety section.
2. Disconnect and ground spark plug leads.
3. Connect VOM to negative (-) battery terminal (A) and terminal (B) of starting motor solenoid. Check for battery voltage. If no battery voltage check for loose connections or corrosion at battery terminals and solenoid terminals. If voltage is present go to the next step.
4. Connect VOM to negative (-) battery terminal (A) and terminal (C) of starting motor solenoid. Momentarily turn ignition switch to START position and check for battery voltage. If voltage is present, starting solenoid is not defective.
5. Connect VOM to negative (-) battery terminal (A) and terminal (D) (Pur wire) of starting motor solenoid. Momentarily turn ignition key to START position and check for battery voltage.

If no voltage is present, go to the next step.

If no voltage is present, check the Pur wire and connections.

If battery voltage is present check the Blk wire and connections between the starting solenoid and frame ground. If connections are OK, starting motor solenoid is defective.

# ENGINE - KAWASAKI (FH491V) REPAIR

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## Results:

- If starter motor solenoid proves defective in the final test, it must be replaced.

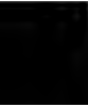


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# ENGINE - KAWASAKI (FH661V, FH721V) SPECIFICATIONS

## Specifications

### General Specifications

#### Specifications:

Make	John Deere "K" Series, Air Cooled
Type	Gasoline
Models	FH661V and FH721V
Cylinders	2
Displacement	675 cm <sup>3</sup> (41.2 cu in.)
Stroke/cycle	4 Cycle
Bore	75.2 mm (2.96 in.)
Stroke	76 mm (2.99 in.)
Compression Ratio	8.1:1
Valves	Overhead
Lubrication	Pressurized
Oil Filter	Full Flow Filter
Engine Oil Capacity With Filter	1.7 L (1.8 US qt)
Engine Oil Capacity With Filter and Oil Cooler	1.9 L (2.0 US qt)
Cooling System	Air Cooled
Air Cleaner	Dual Stage Paper Air Filter and Foam Precleaner
Muffler	Horizontal discharge below frame

### Test and Adjustment Specifications

#### Specifications:

Slow Idle (Governed)	1850 ± 100 rpm
Throttle stop screw setting	1450 rpm
Fast Idle	3350 ± 100 rpm
Minimum Cylinder Compression Pressure	390 kPa (57 psi)
Maximum Difference Between Cylinders	41 kPa (6 psi)
Valve Clearance (Intake and Exhaust) (Cold)	0.075 - 0.125 mm (0.003 - 0.005 in.)
Valve Adjustment Screw Jam Nut Torque	6.9 N•m (61 lb-in.)
Rocker Arm Cover Cap Screw Torque	5.9 N•m (52 lb-in.)
Minimum Exhaust Valve ACR Movement	0.25 mm (0.01 in.)
Minimum Crankcase Vacuum	25 cm (10 in.) water
Oil Pressure at Fast Idle	240 - 310 kPa (35 - 45 psi)
Fuel Pump Minimum Pressure	6.12 kPa (0.90 psi)
Fuel Pump Minimum Flow	65 ml/15 seconds (2.2 oz/15 seconds)
Spark Plug Type	NGK BPR4ES
Spark Plug Gap	0.76 mm (0.030 in.)
Spark Plug Torque	25 N•m (221 lb-in.)

#### Ignition Coil:

Ignition Coil Air Gap	0.25 - 0.40 mm (0.010 - 0.016 in.)
Resistance Between Primary Lead and Core	9 k
Resistance Between Plug Cap and Core	8 - 11 k
Stud torque (If Equipped)	7.8 N•m (69 lb-in.)

# ENGINE - KAWASAKI (FH661V, FH721V) SPECIFICATIONS

Cap Screw Torque ..... 5.9 N•m (52 lb in.)

## Starting Motor:

Amperage (No Load) (Maximum) ..... 50 amps at 5000 rpm

Brush Length (Minimum) ..... 6.4 mm (0.250 in.)

Wire Connection to Solenoid Nut Torque ..... 9.8 N•m (84 lb-in.)

Mounting Bolts ..... 15 N•m (132 lb-in.)

## Repair Specifications

### Cylinder Head:

Cylinder Head Flatness (Maximum Warp) ..... 0.05 mm (0.002 in.)

### Valves and Valve Lifters:

Push Rod Bend (Maximum) ..... 0.5 mm (0.020 in.)

Valve Guide ID (Maximum) ..... 6.08 mm (0.239 in.)

Valve Seating Surface Width Intake ..... 0.8 - 1.4 mm (0.031 - 0.055 in.)

Valve Seating Surface Width Exhaust ..... 1.1 - 1.6 mm (0.04 - 0.06 in.)

Valve Spring Free Length (Minimum) ..... 31.0 mm (1.220 in.)

Valve Margin (Minimum) ..... 0.35 mm (0.014 in.)

Valve Stem Bend (Maximum) ..... 0.05 mm (0.002 in.)

Valve Seat and Face Angle ..... 45°

Valve Narrowing Angle ..... 30°

### Cylinder Bore, Pistons and Rings

#### Ring Groove Side Clearance (Maximum):

Top Ring ..... 0.18 mm (0.007 in.)

Second Ring ..... 0.16 mm (0.006 in.)

Oil Ring ..... 0.20 mm (0.008 in.)

Piston Pin OD (Minimum) ..... 15.96 mm (0.628 in.)

Piston Pin Bore OD (Maximum) ..... 16.08 mm (0.633 in.)

Piston Pin Bearing ID (Maximum) ..... 16.05 mm (0.632 in.)

Piston OD (Standard Piston) ..... 74.99 mm (2.950 in.)

0.50 mm (0.020 in.) Oversize Piston ..... 75.49 mm (2.970 in.)

Cylinder Bore Out of Round Service Limit ..... 0.05 mm (0.002 in.)

### Cylinder Bore ID:

Standard ..... 75.18 - 75.20 mm (2.960 - 2.961 in.)

Wear Limit (Maximum) ..... 75.30 mm (2.965 in.)

0.50 mm (0.020 in.) Oversize Cylinder Bore ..... 75.68 mm (2.980 in.)

Wear Limit (Maximum) ..... 75.78 mm (2.983 in.)

### Piston Rings:

Ring Thickness (Top and Second Ring) (Minimum) ..... 1.40 mm (0.055 in.)

Oil Ring End Gap (Minimum) ..... 0.18 mm (0.007 in.)

#### Ring End Gap (Maximum):

Compression Rings (Top) ..... 0.65 mm (0.026 in.)

Compression Ring (Second) ..... 0.78 mm (0.031 in.)

Oil Ring Side Rails ..... 1.05 mm (0.041 in.)

# ENGINE - KAWASAKI (FH661V, FH721V) SPECIFICATIONS

## Crankshaft:

Crankshaft Runout (TIR) (Maximum) .....	0.05 mm (0.002 in.)
Crankshaft Main Bearing Journal OD (Minimum) .....	39.896 mm (1.571 in.)
Connecting Rod Maximum Crankshaft Bearing ID: .....	38.055 mm (1.498 in.)
Connecting Rod Journal OD (Minimum): .....	37.94 mm (1.494 in.)

## Camshaft:

End Journal OD (Minimum) .....	15.985 mm (0.629 in.)
Lobe Height (Minimum) .....	29.621 mm (1.166 in.)
Bearing ID (Minimum) .....	16.136 mm (0.635 in.)
Maximum Crankcase Cover Plain Bearing ID .....	40.15 mm (1.581 in.)

## Oil Pump:

Rotor Shaft OD (Minimum) .....	10.923 mm (0.430 in.)
Rotor Shaft Bearing ID (Maximum) .....	11.072 mm (0.436 in.)
Outer Rotor Thickness (Minimum) .....	9.830 mm (0.387 in.)
Outer Rotor OD (Minimum) .....	40.47 mm (1.593 in.)
Outer Rotor Bearing Depth (Maximum) .....	10.23 mm (0.403 in.)
Outer Rotor ID (Maximum) .....	40.80 mm (1.606 in.)
Relief Valve Spring Free Length (Minimum) .....	19.50 mm (0.775 in.)

## Torque Specifications

*Note: Use appropriate torque wrench which will read within the inch pound range given, or convert inch pounds to foot pounds as follows: Inch-pounds/12 = Foot-pounds*

## Specifications:

Engine Mounting Cap Screw Torque .....	26 N•m (230 lb-in.)
Flywheel Bolt Torque .....	56 N•m (41 lb-ft)
Cylinder Head Cap Screw Torque in Sequence (Lubricated)	
New Cap Screws - Final Torque .....	32 N•m (24 lb-ft)
Reuse Cap Screws - Final Torque .....	25 N•m (18 lb-ft)
Crankcase Cover Cap Screw Torque .....	22 N•m (17 lb-ft)
Oil Drain Plug Torque .....	20 N•m (171 lb-in.)
Connecting Rod Cap Screw Torque .....	9.8 N•m (87 lb-in.)
Governor Lever Nut Torque .....	7.8 N•m (69 lb-in.)
Intake Manifold Mounting Cap Screws .....	5.9 N•m (52 lb-in.)

# ENGINE - KAWASAKI (FH661V, FH721V) TOOLS AND MATERIALS

## Tools and Materials

### Tools

**Note:** Order tools according to information given in the U.S. SERVICE-GARD<sup>®</sup> Catalog or in the European Microfiche Tool Catalog (MTC).

### Special or Required Tools

Tool Name	Tool No.	Tool Use
Hand-Held Digital Tachometer	JT05719	Used to check idle speed and starter performance.
Compression Gauge	JDM59	Used to check engine compression.
Vacuum Gauge	JT03503	Used to check engine crankcase vacuum.
90° Elbow Fitting	JT03338	Used to connect pressure gauge to engine when performing Engine Oil Pressure Test.
Hose Assembly	JT03017	Used to connect pressure gauge to engine when performing Engine Oil Pressure Test.
Pressure Gauge Assembly	JT03344	Used to read engine oil pressure when performing Engine Oil Pressure Test.
Pressure Gauge	JDG356	Used to check fuel pump performance.
Spark Tester	D-05351ST	Used to check overall condition of ignition system.
Valve Spring Compressor	JDM70	Used to remove and install valve springs.
Current Gun	JT05712	Used to check starter performance.

## Other Materials

### Other Material

Part No.	Part Name	Part Use
TY24416	Multipurpose Lithium Grease	Apply to engine crankshaft
	SCOTCH-BRITE <sup>®</sup> Abrasive Sheets/Pads	Clean cylinder head
	Valve Guide Cleaner	Clean valve guides
	Prussian Blue Compound	Check valve seat contact
TY24416	Lithium Base Grease	Pack oil seals
	Zinc Oxide/Wood Alcohol	Check block for cracks
	Mineral Spirits	Clean armature
	Valve Lap Compound	Lap valves
PM37418 LOCTITE 242	Thread Lock and Sealer (Medium Strength)	Apply to threads of throttle and choke plate screws
PM37565 LOCTITE 587 Canada PM38616	RTV Silicone Form-in-Place Gasket	Rocker arm cover mating surfaces
PM37397 LOCTITE 592	Thread Sealant (General Purpose) with TEFLON,	Apply to threads of pipe plugs

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SCOTCH-BRITE is a registered trademark of the 3M Co.

TEFLON<sup>®</sup> is a registered trademark of DuPont.

### Service Parts Kits

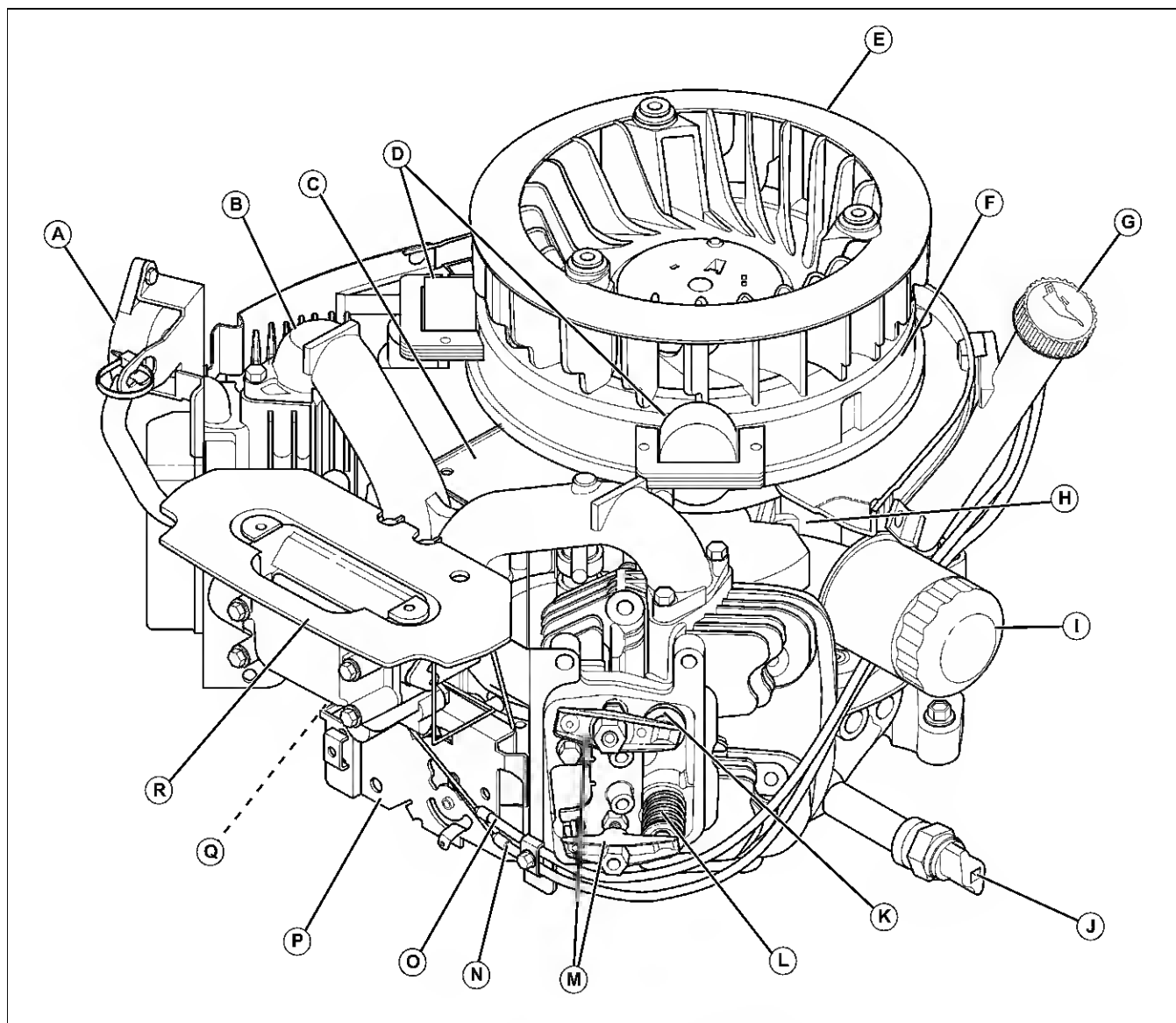
The following kits are available through your parts catalog:

- Carburetor
- Gasket Kit
- High Altitude Carburetor Kit

# ENGINE - KAWASAKI (FH661V, FH721V) COMPONENT LOCATION

## Component Location

### Engine Components



MX37448

A- Fuel Pump  
B- Cylinder Air Intake  
C- Breather Cover

D- Ignition Coils  
E- Flywheel Fan  
F- Flywheel  
G- Oil Dipstick  
H- Oil Pressure Switch Location (if installed)  
I- Oil Filter  
J- Oil Drain  
K- Intake Valve  
L- Exhaust Valve

M- Rocker Arms  
N- Throttle Cable  
O- Choke Cable  
P- Plate  
Q- Fuel Shutoff Solenoid  
R- Carburetor Air Filter Base





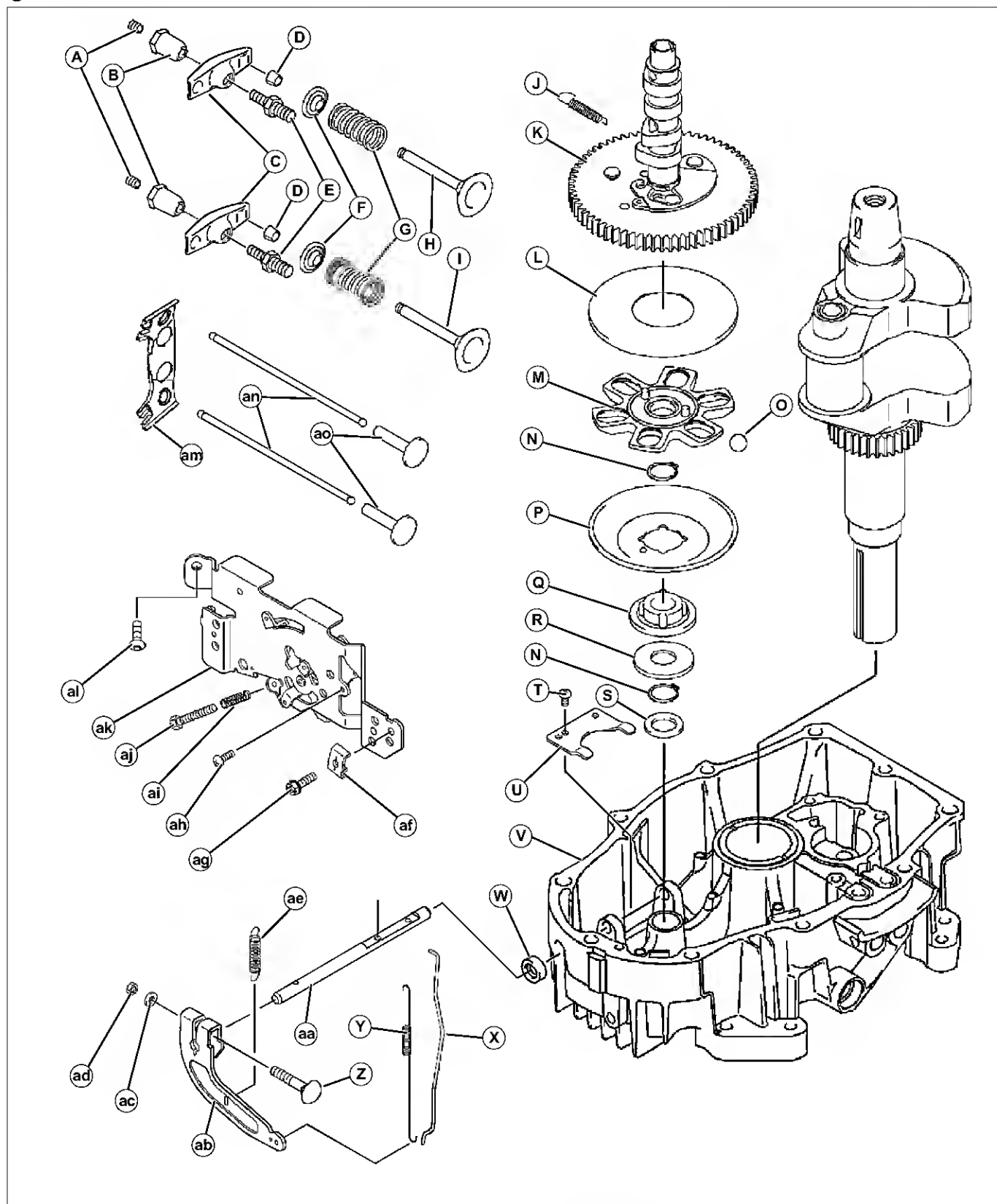
## ENGINE - KAWASAKI (FH661V, FH721V) COMPONENT LOCATION

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V- Crankcase Cover  
W- Seal  
X- Bolt  
Y- Seal  
Z- Head  
AA- Gasket  
AB- Oil Filter Adaptor  
AC- Plug  
AD- Block  
AE- Seal  
AF- Valve  
AG- Retainer  
AH- Screw M4x8  
AI- Filter Element  
AJ- Gasket  
AK- Cover  
AL- Screw M6x12

# ENGINE - KAWASAKI (FH661V, FH721V) COMPONENT LOCATION

## Engine Valves and Governor



MX38129

A- Lock Screw  
B- Rocker Nut

C- Rocker Arm  
D- Spring Colette

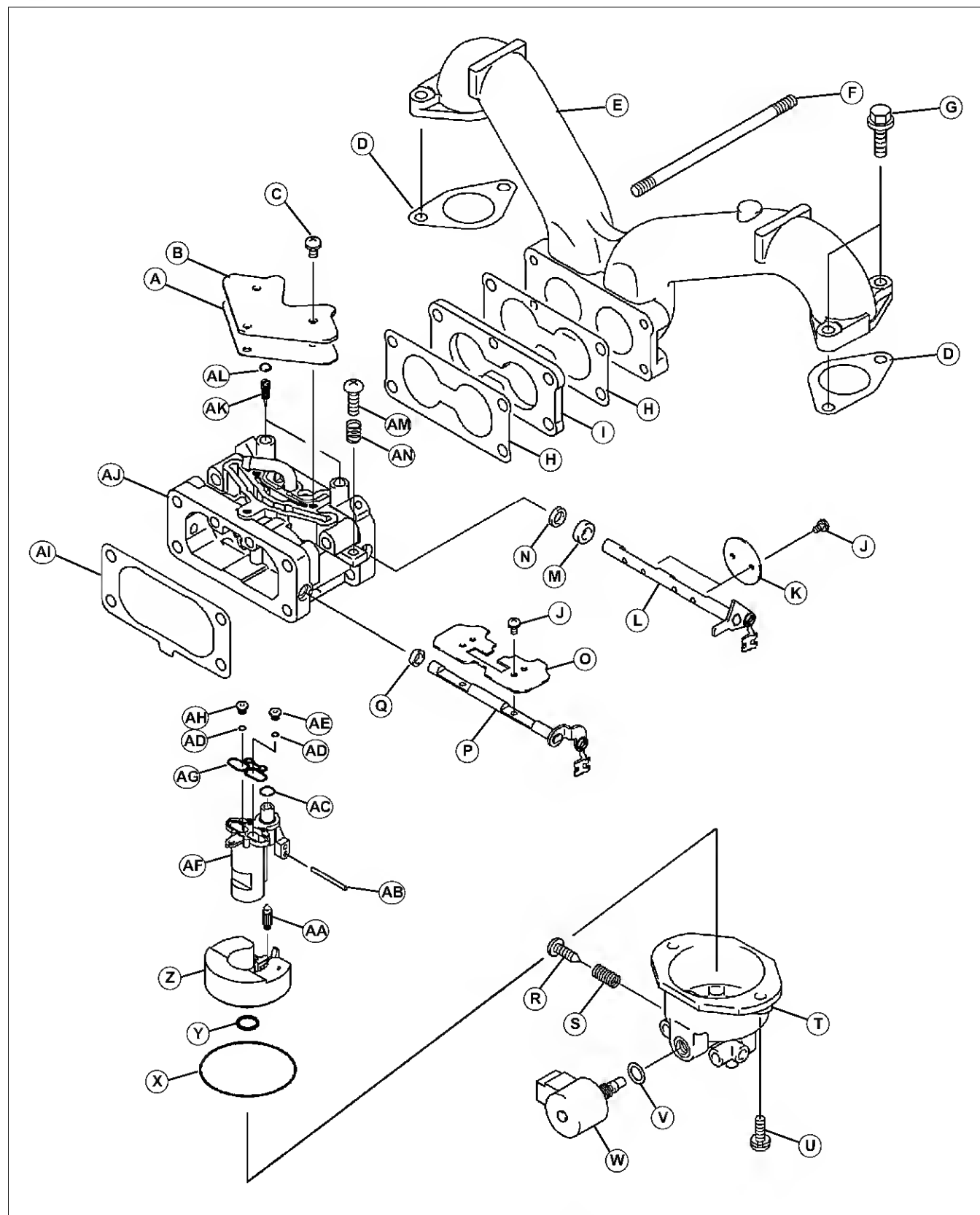
## ENGINE - KAWASAKI (FH661V, FH721V) COMPONENT LOCATION

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E- Stud  
F- Spring Retainer  
G- Valve Spring  
H- Intake Valve  
I- Exhaust Valve  
J- Spring  
K- Cam Shaft  
L- Plate  
M- Guide  
N- Snap Ring  
O- Ball  
P- Concave Plate  
Q- Sleeve  
R- Washer (FH721V engines)  
S- Washer (engine model specific)  
T- Screw  
U- Retainer  
V- Sump  
W- Seal  
X- Governor Link  
Y- Governor Spring  
Z- Screw  
AA- Governor Shaft  
AB- Governor Arm  
AC- Washer  
AD- Nut  
AE- Spring  
AF- Cable Retainer  
AG- Screw  
AH- Screw  
AI- Spring  
AJ- Screw  
AK- Plate  
AL- Screw  
AM- Pushrod Guide  
AN- Pushrod  
AO- Tappets

# ENGINE - KAWASAKI (FH661V, FH721V) COMPONENT LOCATION

## Carburetor



MX36426

A- Gasket<sup>1</sup>

B- Cover

C- Screw

## ENGINE - KAWASAKI (FH661V, FH721V) COMPONENT LOCATION

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D- Gasket (2 used)1  
E- Intake Manifold  
F- Stud or Bolt (2 of each used)  
G- Bolt (4 used)  
H- Gasket (2 used)1  
I- Insulator1  
J- Screw (6 used)  
K- Throttle Valve (2 used)  
L- Throttle Shaft  
M- Collar  
N- Seal1  
O- Valve Plate  
P- Choke Shaft  
Q- Seal1  
R- Drain Screw  
S- Spring  
T- Float Bowl  
U- Screw (2 used)  
V- O-Ring1  
W- Solenoid  
X- Gasket1  
Y- O-Ring1  
Z- Float  
AA- Float Valve1  
AB- Pin  
AC- O-Ring1  
AD- O-Ring (2 used)1  
AE- Main Jet, Right<sup>2</sup>  
AF- Spacer  
AG- Gasket1  
AH- Main Jet, Left<sup>2</sup>  
AI- Gasket1  
AJ- Carburetor Body  
AK- Needle Jet  
AL- Plug, Expansion  
AM- Screw  
AN- Spring

1. Parts included in carburetor kit.

2. For altitude changes, see Parts Catalog for jet numbers.

## Engine Shields

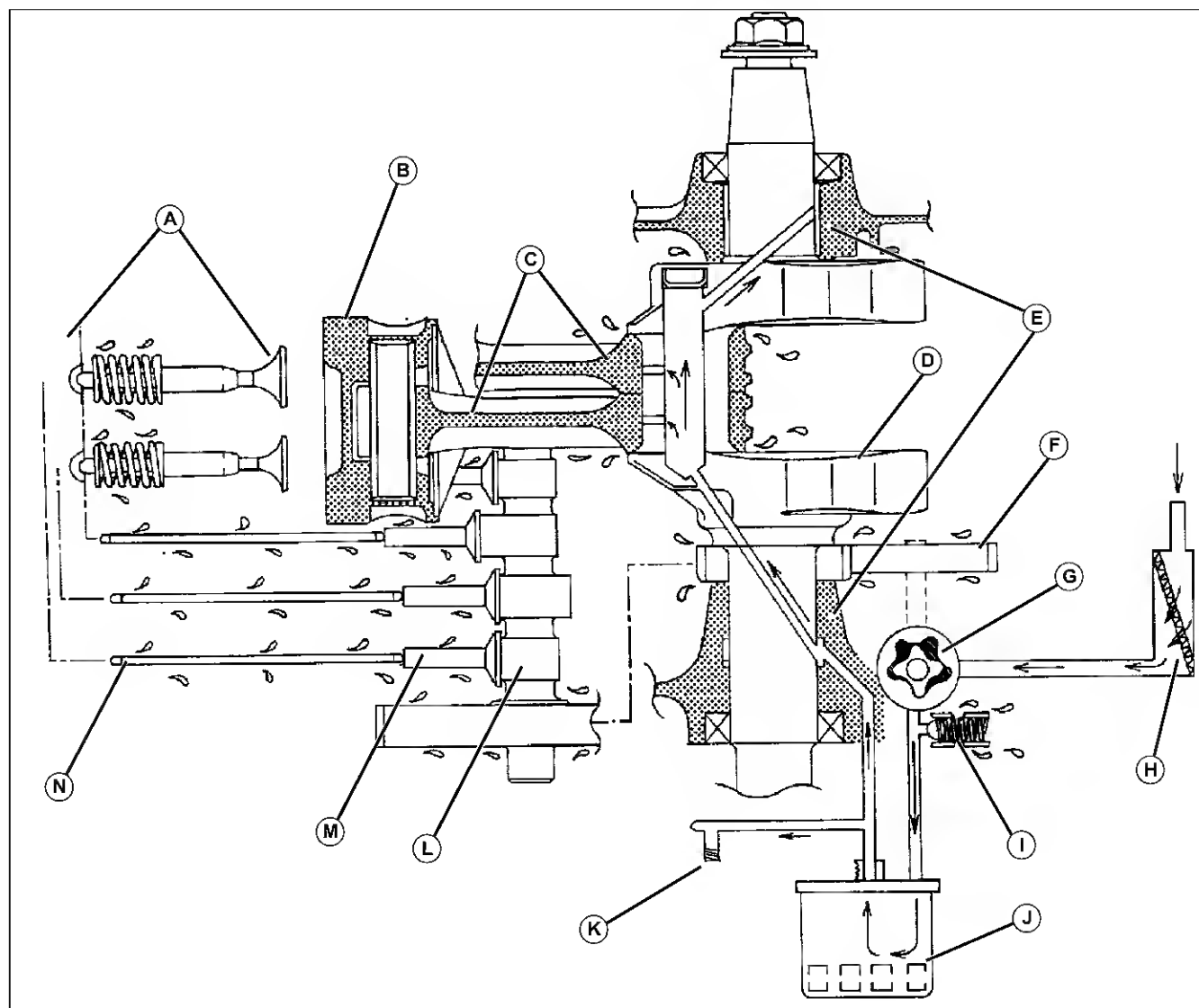


- A- Muffler
- B- Gasket (2 used)
- C- Flange Nut M8 (4 used)
- D- Screw (6 used)
- E- Engine Base Plate
- F- Clip Nut (8 used)
- G- Screw M6x25
- H- Shield LH
- I- Screw M6x12
- J- Shield, Upper
- K- Screw (6 used)

# ENGINE - KAWASAKI (FH661V, FH721V) THEORY OF OPERATION

## Theory of Operation

## Engine Oil Flow Chart



M99565a

- A- Rocker Arms and Valves
- B- Piston
- C- Connecting Rods
- D- Crankshaft
- E- Crankshaft Main Bearings
- F- Oil Pump Gear
- G- Oil Pump
- H- Pick-up Screen
- I- Oil Pressure Relief Valve
- J- Oil Filter
- K- Oil Pressure Port - Plugged
- L- Camshaft
- M- Tappets
- N- Push Rods

# ENGINE - KAWASAKI (FH661V, FH721V) THEORY OF OPERATION

## Lubrication System Operation

### Function:

To provide pressurized oil to lubricate internal engine components.

### Theory of Operation:

A positive displacement gerotor pump is used to pressurize the lubrication system. The lubrication system is protected by an oil pressure relief valve and an oil filter with bypass valve.

The oil pump draws oil from the sump through the pick-up screen. Pressure oil from the pump flows through the pump outlet passage past the oil pressure relief valve. The oil pressure relief valve limits the oil pressure to approximately **296 kPa (43 psi)** and protects the oil pump from damage if an oil passage becomes blocked. If the oil pressure exceeds 296 kPa (43 psi), the relief valve opens allowing oil to return to the sump. The relief valve is not adjustable.

Pressure oil flows past the relief valve to the oil filter. The filter contains a bypass valve which opens at **78.5 - 117.5 kPa (11.4 - 17.1 psi)** if the element becomes plugged to ensure engine lubrication.

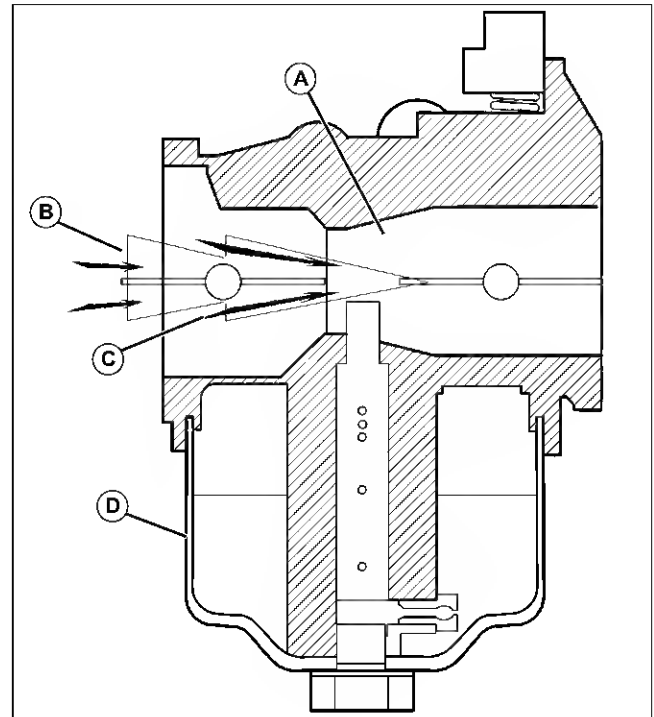
An oil pressure port (some models) is provided to attach an auxiliary pressure gage to check oil pressure. Filtered pressure oil flows through a passage in the oil sump to the crankshaft main bearing (PTO side). Drilled passages in the crankshaft distribute oil from the main bearings to the connecting rod journals and crankshaft main bearings (flywheel side). A drilled passage in the connecting rods allows oil from the connecting rod journal to lubricate the piston and cylinder walls.

In the cylinder head, the rocker arms, valves, and pushrods are lubricated by an oil/air mixture carried through an upper lubrication passage from the breather chamber. As this oil/air mixture is swirled around the rocker arm chamber, the oil particles cling to the moving parts, lubricating them. Eventually these oil particles collect into a liquid state again in the lower portion of the rocker arm chamber. A small return passage is provided to return this liquid state oil back into the crankcase.

The camshaft gear, camshaft, tappets, coolant pump gear, governor gear, oil pump gear, and crankshaft gear are lubricated by oil splash generated by the internal moving parts during operation.

## Carburetor Operation

### Function



MX47326

- A- Venturi
- B- Carburetor Throat
- C- Increased Air Speed
- D- Fuel Bowl

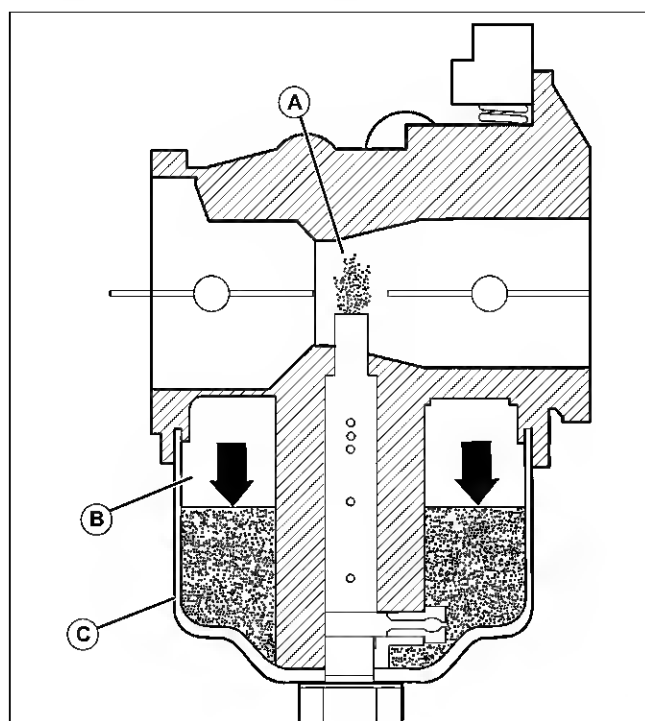
The function of the carburetor is to create fuel flow, atomize the fuel, and meter the air/fuel mixture so it can be combusted in the engine. To create fuel flow through the carburetor, there must be a pressure differential between the fuel bowl and the throat of the carburetor.

### Venturi

Air goes through the carburetor throat. When it reaches the venturi, the air speed is increased and the air pressure is decreased. The venturi is a restriction in the carburetor located between the choke and throttle valves. The restriction causes air to speed up resulting in a lower than atmospheric pressure area in the carburetor throat.



# ENGINE - KAWASAKI (FH661V, FH721V) THEORY OF OPERATION



MX47327

- A- Venturi Low Pressure
- B- High Pressure
- C- Fuel Bowl

A vent passage in the carburetor maintains pressure from the atmosphere on the fuel in the fuel bowl. Since fluids flow from areas of higher pressure to areas of lower pressure the resulting pressure differential between the fuel bowl (high pressure) and the venturi (low pressure), causes fuel to be pushed (flow) from the fuel bowl to the venturi.

There are two types of bowl venting: external and internal.

**Note: Late model carburetors are internally vented to meet emissions standards.**

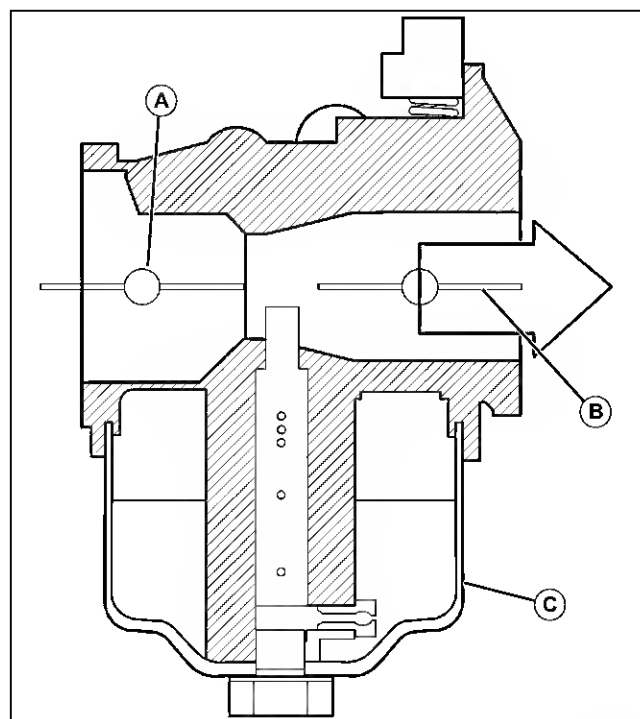
Externally vented carburetors exert direct atmospheric pressure from outside of the air filter onto the fuel in the bowl.

Internally vented carburetors exert indirect atmospheric pressure from inside the air filter, ahead of the choke valve, onto the fuel in the bowl.

## Fuel Bowl and Float

The fuel bowl is the fuel reservoir for the carburetor. In order to maintain the proper fuel air/mixture, the fuel level must be constant. The float maintains the level of fuel in the bowl while regulating the fuel flow to match the demands of the engine by controlling the inlet float valve (needle).

## Control Valves



MX47328

- A- Choke Valve
- B- Throttle Valve
- C- Fuel Bowl

The carburetor has two control valves: throttle valve and choke valve.

The throttle valve is operated by the throttle lever and controlled by the governor. The throttle valve controls how much air and fuel enters the cylinder(s).

The choke valve, located before the venturi, creates a restriction when closed. The function of the choke valve is to increase the pressure differential between the fuel bowl and the venturi area. This results in increased fuel flow from the bowl to the venturi, enriching the air/fuel mixture.

In some engines, a primer is used in place of a choke valve to push fuel into the venturi.

## Concept of Idle

Governed engines are designed to maintain a specific engine speed.

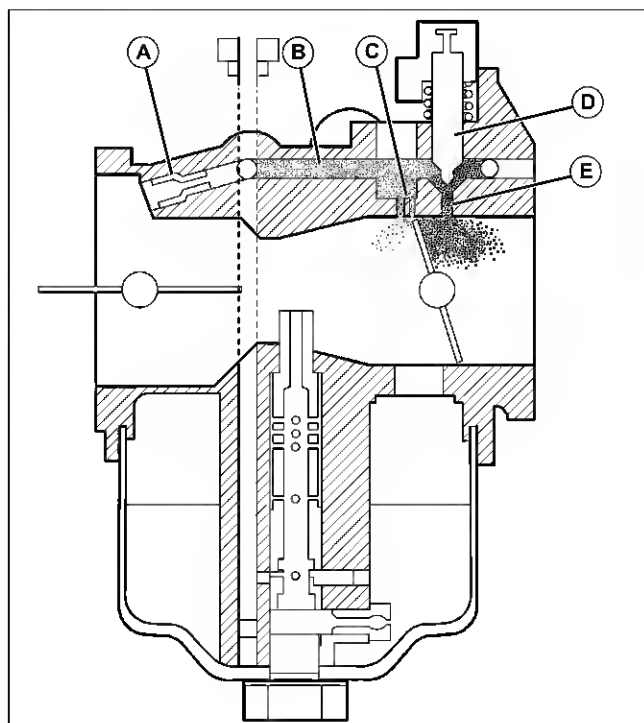
Governed engines with no load (PTO disengaged, drive in neutral) are said to be at "idle" regardless of engine speed. When the operator selects the low speed position with no load, the engine is at low idle. When the operator selects the high speed position with no load, the engine is at high idle.

Carbureted engines account for these situations with two circuits; an idle circuit (no load) and a main circuit (under

# ENGINE - KAWASAKI (FH661V, FH721V) THEORY OF OPERATION

load).

## Idle Circuit



MX47329

- A- Air Bleed
- B- Idle Circuit
- C- Transitional Bypass Openings
- D- Pilot Valve
- E- Pilot Opening

The idle circuit, on a governed engine, delivers air and fuel primarily when the engine is not under load (PTO disengaged, drives in neutral).

Fuel flow enters the idle circuit from the main jet but is metered by the idle jet. The fuel is then emulsified with air passing through an air bleed and combining with the fuel. The air/fuel mixture travels to the transitional bypass openings and the pilot opening.

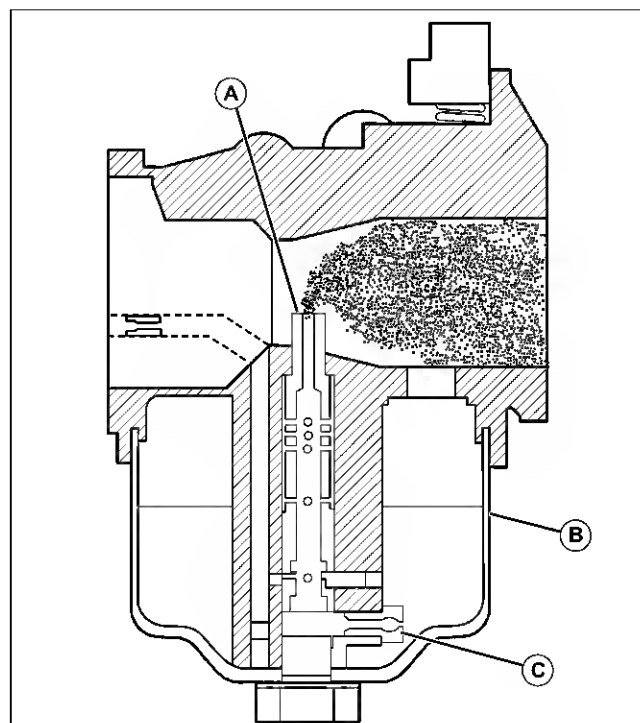
When the throttle valve is closed, the engine receives its air/fuel mixture through the pilot opening. The pilot opening is used for low idle operation. The pilot opening is located between the closed throttle plate and the intake manifold. The opening has a pilot screw that allows for some adjustment. This adjustment primarily affects low idle.

When the governor slightly opens the throttle valve for high idle or when a load is applied, the transitional bypass openings are exposed. These additional openings increase air/fuel flow to the engine.

Once the engine is under a heavier load, the throttle valve is opened beyond the transitional bypass openings. At this point the carburetor receives fuel primarily from the main

circuit.

## Main Circuit



MX47330

- A- Emulsion Tube
- B- Fuel Bowl
- C- Main Jet

The main circuit, on a governed engine, is used only when the engine is under load. Fuel flows from the fuel bowl through the fixed main jet into the main circuit.

Air enters through a metered orifice (air-bleed) and emulsifies (mixes) air and fuel as it travels up the emulsion tube to the venturi.

Emulsification is an important process to properly atomize the fuel and promote efficient combustion.

## Fuel Shutoff Solenoid

The fuel shut-off solenoid reduces fuel flow to the main circuit. The function of the fuel shut-off solenoid is to minimize after-bang.

At engine start up, the fuel shut-off solenoid is energized and the poppet retracts from the seat in the bowl, allowing fuel to enter into the main jets.

To bench test the fuel shut-off solenoid, apply light pressure to the tip to simulate its mounting in the fuel bowl and apply 12 volts DC. If the needle retracts, the solenoid is working. Verify the tip is secured to the plunger.

# ENGINE - KAWASAKI (FH661V, FH721V) DIAGNOSTICS

## Diagnostics

### Engine Troubleshooting Guide



**Caution: Avoid Injury! The engine may start to rotate at any time. Keep hands away from moving parts when testing.**

**Note: To test specific electrical components, see Electrical Section and refer to either Diagnostics or Tests & Adjustments for further guidance.**

Test Conditions:

- Operator on seat.
- PTO switch in off position.
- Brake on.

### Engine Diagnostics

#### Engine Doesn't Crank

1. Are battery cables loose or dirty?

Yes: Tighten or clean.

No: Go to next step

2. Is battery fully charged? See "Battery Test" on page 343 in the Electrical section.

Yes: Go to next step

No: Charge Battery. See "Charge Battery" on page 344 in the Electrical Section.

3. Is key switch working correctly?

Yes: Go to next step.

No: Test Switch, Replace as needed.

4. Is starter motor defective? See "Starting Motor Troubleshooting Guide" on page 102.

Yes: Repair or replace.

No: Go to next step.

5. Is starting motor or solenoid defective?

Yes: Repair or replace. See "Starting Solenoid Test" on page 349 in the Electrical section.

No: Go to next step.

6. Are operating conditions met, or is there a open circuit in wiring? See "Cranking Circuit Operation" on page 239 in the Electrical section.

Yes: Diagnose and repair as necessary. See "Cranking Circuit Diagnostics" on page 241.

No: Go to next step.

7. Are the valves adjusted properly?

Yes: Go to next step.

No: Adjust valve clearance. See "Valve Clearance Check and Adjustment" on page 111.

8. Is engine compression good? See "Cylinder Compression Pressure Test" on page 113. Perform leak-down test. See "Cylinder Leak-Down Test" on page 112.

Yes: Go to next step.

No: Check for seized or burned valves, broken piston rings, or worn cylinder

9. Has engine seized?

Yes: See engine Repair Section.

#### Engine Hard To Start, Backfires or Misses

1. Are battery cables loose or dirty?

Yes: Repair.

No: Go to next step.

2. Is battery fully charged? See "Battery Test" on page 343 in the Electrical section.

Yes: Go to next step

No: Charge Battery. See "Charge Battery" on page 344 in the Electrical Section.

3. Is there a strong blue spark? See "Spark Test" on page 349 in the Electrical section.

Yes: Go to next step.

No: Check spark plug wire(s) for proper seating and connections. Check ignition coil gap. See "Ignition Coil Air Gap Adjustment" on page 116. Adjust gap, or replace ignition module.

4. Are sparks jumping between high tension lead and ignition block. Check high tension lead and ignition coil air gap.

Yes: Repair or Replace parts as needed

No: Go to next step

5. Is the fuel shutoff solenoid operating correctly? See "Fuel Shutoff Solenoid Test" on page 352 in the Electrical section.

Yes: Go to next step.

No: Repair or replace.

6. Is the fuel filter or fuel line clogged?

Yes: Clean or replace as necessary.

No: Go to next step.

7. Is the fuel pump operating correctly? See "Fuel Pump Test" on page 115.

# ENGINE - KAWASAKI (FH661V, FH721V) DIAGNOSTICS

Yes: Go to next step.

No: Clean or replace as necessary.

8. Is their water in the fuel?

Yes: Drain and replace fuel.

No: Go to next step.

9. Is air sucked through carburetor or intake manifold flanges?

Yes: Tighten manifold flange nuts or replace damaged gasket.

No: Go to next step.



**Caution: Avoid Injury! Keep spark plug as far away from the plug hole as possible. Gasoline spray from the open cylinders may be ignited by ignition spark and cause an explosion or fire.**

10. Make starting attempts a number of times, remove spark plug and observe electrodes. After starting attempts, are spark plug electrodes wet?

Yes: Check for excessive use of choke, plugged air cleaner, float bowl level too high.

No: Go to next step

11. Are the valves set correctly? See "Valve Clearance Check and Adjustment" on page 111.

Yes: Go to next step.

No: Check push rods and adjust valves. See "Valve Clearance Check and Adjustment" on page 111. Repair or replace parts as needed.

12. Is engine compression good? See "Cylinder Compression Pressure Test" on page 113. Perform cylinder leak-down test. See "Cylinder Leak-Down Test" on page 112.

Yes: Remove flywheel and inspect flywheel key. See "Flywheel Removal and Installation" on page 126.

No: Check piston rings and cylinder for wear. See "Piston Inspection:" on page 136. Inspect Cylinder head. See "Cylinder Head Inspection" on page 131.

## Engine Runs Erratically

1. Does the engine smooth out if partial choke is applied?

Yes: Go to next step.

No: Check for proper governor adjustment. See "Governor Adjustment" on page 110.

2. Is fuel delivery correct? See "Fuel Pump Test" on page 115.

Yes: Go to next step.

No: Check for defective fuel pump, plugged fuel lines, fuel filter, or fuel tank vent.

3. Is fuel present in carburetor?

Yes: Go to next step.

No: Check for plugged air/fuel passages in carburetor. See "Carburetor Removal and Installation" on page 119.

4. Is the fuel stale or is there contamination in fuel lines, or fuel tank?

Yes: Replace fuel and clean or replace parts as needed.

No: Go to next step

5. Is air leaking through carburetor connections or intake manifold flanges?

Yes: Tighten manifold flange nuts or replace damaged gasket.

## Engine Malfunctions At Low Speed

1. Is unusual smoke emitted out of muffler?

Yes: Check Choke. See "Choke Plate Check and Adjustment" on page 109.

No: Go to next step.

2. Does engine rpm drop or engine stall at a certain point when throttle is gradually opened by hand?

Yes: Check for obstruction or plugged passage in carburetor. See "Carburetor Removal and Installation" on page 119.

No: Go to next step.

3. Is air sucked through carburetor or intake manifold flanges?

Yes: Tighten manifold flange nuts or replace damaged gasket.

No: Go to next step

4. Are valve clearances set correctly? See "Valve Clearance Check and Adjustment" on page 111.

No: Adjust valves.

## Engine Dies After Running

1. Does engine die after running 20 seconds or less?

Yes: Check choke. See "Choke Plate Check and Adjustment" on page 109.

Yes: Check for stale fuel or contamination. Replace fuel and clean or replace parts as needed.

No: Go to next step.

2. Does engine die after running 10 minutes or more under load?

Yes: Check fuel lines for obstruction, plugged passage

# ENGINE - KAWASAKI (FH661V, FH721V) DIAGNOSTICS

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or collapsed fuel line. Test fuel pump. See "Fuel Pump Test" on page 115.

Yes: Check all shielding is in place and fuel line is run away from heat sources.

Yes: Perform cylinder leak-down test. See "Cylinder Leak-Down Test" on page 112.

## Oil Consumption Is Excessive

1. Check for oil leaks, high oil level, clogged breather valve, plugged drain back hole in breather, Is oil viscosity correct?

Yes: Repair as required.

No: Go to next step.

2. Is compression correct? See "Cylinder Compression Pressure Test" on page 113.

No: Check for worn, stuck, or broken piston rings, or worn cylinder bore.

## Low Oil Pressure

1. Is oil level correct?

Yes: Go to next step.

No: top off oil to correct level.

2. Is oil filter clogged?

Yes: Replace Oil Filter.

No: Go to next step.

3. Is oil of correct viscosity?

Yes: Go to next step.

No: Change engine oil.

4. Check for oil leaks, high oil level, clogged breather valve, plugged drain back hole in breather, Is oil viscosity correct?

Yes: Repair as required.

No: Go to next step.

5. Is oil relief valve worn?

Yes: Clean, adjust or replace relief valve.

No: Go to next step.

6. Is oil pump operating correctly? See "Engine Oil Pressure Test" on page 114.

Yes: Go to next step.

No: Replace oil pump.

7. Is there fuel in the oil?

Yes: Check for broken or seized piston Rings or worn cylinder.

No: Go to next step.

8. Is oil pump screen clogged or pick up tube cracked?

Yes: Clean screen and repair or replace pick up tube.

No: Go to next step.

9. Is there excessive crankshaft or rod bearing clearance? See "Crankshaft and Main Bearings" on page 140.

Yes: Replace worn crankshaft and/or worn connecting rods.

No: Go to next step.

10. Intake/exhaust valves or guides worn?

Yes: Replace valves and head.

## Contamination in Crankcase

1. Is there fuel in the crankcase?

Yes: Check for broken or seized piston rings or worn cylinder. Check for worn or seized exhaust valve.

No: Go to next step.

2. Is there water in the crankcase?

Yes: Check to make sure that crankcase breather is working correctly. See "Crankcase Vacuum Test" on page 114. See "Breather Removal and Installation" on page 127.

# ENGINE - KAWASAKI (FH661V, FH721V) DIAGNOSTICS

## Starting Motor Troubleshooting Guide



**Caution: Avoid Injury!** The engine may start to rotate at any time. Keep hands away from moving parts when testing.

**Important: Avoid Damage!** If starting motor does not stop rotating by turning ignition switch to Off position, disconnect negative (-) lead from battery as soon as possible.

**Note:** To test specific electrical components, see *Electrical Section* and refer to either *Diagnostics or Tests & Adjustments* for further guidance.

### Starting Motor Diagnostics

#### Starter Does Not Rotate

1. Is there a click sound from the starter solenoid?

Yes: Go to next step.

No: Repair starter motor. See "Starting Motor Removal and Installation" on page 148.

2. Check that all starting conditions are met?

Yes: Go to next step.

No: Make sure all starting conditions are met.

3. Are battery cables loose or dirty?

Yes: Clean and Tighten.

No: Go to next step.

4. Is battery fully charged? See "Battery Test" on page 343 in the Electrical Section.

Yes: Go to next step.

No: Charge Battery. See "Charge Battery" on page 344 in the Electrical section.

5. Is key switch working correctly?

Yes: Go to next step.

No: Repair or replace key switch

6. Is engine seized?

Yes: See Engine Repair Section.

#### Starter Rotates Slowly

1. Are battery cables loose or dirty?

Yes: Clean and tighten.

No: Go to next step.

2. Is battery fully charged? See "Battery Test" on page 343 in the Electrical Section.

Yes: Go to next step.

No: Charge Battery. See "Charge Battery" on page 344 in the Electrical section. Check for charging voltage to battery. See "Regulated Voltage Test" on page 345 in the Electrical Section.

3. Is there a click sound from the starter solenoid?

Yes: Go to next step.

No: Repair starter motor. See "Starting Motor Removal and Installation" on page 148.

4. Is engine seized?

Yes: See engine Repair section.

No: Go to next step

5. Is starting motor or solenoid defective? See "Starting Solenoid Test" on page 349 in the Electrical section.

Yes: Repair or replace.

## Carburetor Troubleshooting Guide

### Engine Will Not Start

1. Is there fuel?

Yes: Go to next step.

No: Add fuel, check fuel lines.

2. Is fuel line plugged?

Yes: Clean fuel line and fuel filter. Check for fuel supply at carburetor.

No: Go to next step.

3. Does the fuel solenoid open?

Yes: Go to next step.

No: Test solenoid and power to solenoid. See Electrical section.

4. Is the main jet clogged?

Yes: Disassemble and clean jet and passages.

No: Go to next step.

5. Is the needle valve stuck closed?

Yes: Check for old or gummy fuel. Clean carburetor. Check valve tip.

No: Go to next step.

### Engine Cranks But Is Hard to Start

1. Is the air filter clean?

Yes: Go to next step.

No: Clean or replace air filter.

2. Is the choke plate opening properly?

Yes: Go to next step.

# ENGINE - KAWASAKI (FH661V, FH721V) DIAGNOSTICS

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No: Adjust choke cable. See choke cable and throttle cable adjustment.

3. Check passages in carburetor. Are passages open and free of debris or varnish?

No: Clean carburetor.

## Engine Idles But Does Not Run Under Load

1. Check main jet. Is main jet dirty?

Yes: Clean carburetor.

No: Go to next step.

2. Check main jet for proper size. Is correct main jet used?

No: Replace main jet.

## Engine Idles, Runs (loaded or not) Then Stops

1. Is the fuel system properly vented?

Yes: Go to next step.

No: Check fuel cap if vented cap is used. Check vent lines to carburetor for kinks, or collapsed or weak areas.

2. Is dirt in the bowl being sucked into main jet?

Yes: Check float bowl for dirt or corrosion, clean bowl. Check main jet for loose debris.

## Engine Does Not Idle Properly (hunts or surges)

1. Check to see if the problem is governor or carburetor: Hold the throttle plate closed to force engine to idle. Does the engine continue to run? check governor. If the engine stalls - suspect idle circuit.

Yes: Check governor for proper operation.

No: If engine stalls, check idle circuit. Clean carburetor with attention to idle circuit passages.

## Engine Idles, Does Not Run Properly At Wide Open Throttle (WOT)

1. Check float bowl for dirt or corrosion. Check for dirt between needle valve and seat. Is dirt or debris present?

Yes: Clean bowl and valve seat.

No: Go to next step.

2. Is float sticking or not set properly?

Yes: Clean float pivot. Adjust float.

No: Go to next step.

3. Check air passage and pilot jet for debris or varnish. Is there debris in the idle air bleed or pilot jet?

Yes: Clean carburetor.

## Carburetor Air/Fuel Diagnosis

Defects in carburetors would be apparent very early in the life of the engine. The majority of fuel system problems are related to stale or improper fuel or dirt. This section is to help you diagnose fuel system problems.

### Initial Checklist

- How old is the fuel?
- Does the fuel have a foul smell?
- Is the fuel cloudy, dark or dirty?
- Is the fuel tank cap air vent clean and open?
- Is a clean, correct air filter installed?
- Has the ignition system been verified?
- Is the air filter and carburetor attached properly?
- Is the intake manifold loose and/or leaking?
- Is the fuel shut-off solenoid operating properly?
- Is the governor throttle linkage moving properly?
- Is the float operating properly?
- If the carburetor is externally vented, is the vent line unrestricted?

**Note: Other engine failures such as plugged exhaust or improper valve clearance can cause symptoms similar to faulty fuel supply. Verify the quality of the engines mechanical and electrical systems.**

### Engine Surge

An engine that surges may have an improper air/fuel mixture or a misadjusted or worn governor.

Attempt to manually control the throttle at low and high idle to determine which system is causing the surge. If the engine speed can be held constant check the governor system. If the engine surge cannot be controlled manually, check the fuel system.

Fuel system issues may consist of:

- Improper air/fuel mixture caused by air leaks around the throttle shaft, intake and/or insulator gaskets.
- Minor restrictions inside the carburetor passages from varnish and debris buildup in the idle circuit. Properly cleaning the carburetor will likely fix the problem.

### Rich Air/Fuel Mixture

There are several possible causes of a rich running condition such as: improper or stale fuel, short-tripping, air filter, choke adjustment and/or vent tube location.

**Note: Verify the ignition system. A rich running condition can have the same symptoms as an improperly operating ignition system.**

# ENGINE - KAWASAKI (FH661V, FH721V) DIAGNOSTICS

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## Float Valve



MX47331

### Float Valve with Worn Tip Shown

Fuel level in the float bowl is regulated by the float and the float valve. A worn float valve tip provides too much fuel and will cause a rich condition.

### Improper or Stale Fuel

Poor fuel quality can cause an engine to appear to be running rich. Improper or stale fuel can cause engine components to stick or deteriorate.

### Short-Tripping

A common misdiagnosis comes from short-tripping machines (engines that are started for short periods of time). Short-tripping causes the engine to develop black, sooty spark plugs and contamination in the oil. Over time, short-tripping can lead to glazed cylinder walls. To prevent this, every time the engine is started, allow the engine to reach operating temperature and load the machine.

### Air Filters

***Note: Late model carburetors are internally vented to meet emissions standards.***

Engines with externally vented carburetors with a dirty air filter will exhibit rich running conditions. When a dirty air filter restricts air flow to the carburetor, the low pressure in the venturi drops even further, resulting in a higher pressure differential between the fuel bowl and the venturi. Therefore, a dirty air filter can enrich the air/fuel mixture to the point that performance will drop.

Engines with internally vented carburetors will not exhibit rich running conditions with a dirty air filter. When a dirty air filter restricts air flow to the throat of the carburetor, an equal reduction will be applied to the bowl vent. Internally vented carburetors maintain the pressure differential between the bowl and the venturi resulting in a consistent air/fuel mixture over the life of the air filter.

## Vent Tube Location

With an externally vented carburetor, a rich or lean run condition could also be caused by the location of the float bowl vent tube. The purpose of the vent tube is to allow atmospheric pressure into and out of the float bowl. Air from the cooling fan at the vent tube opening can cause a pressure increase or decrease on the fuel in the float bowl and cause the engine to run rich or lean. Check for bulletins and relocate the float bowl vent tube to a location away from any source of turbulence.

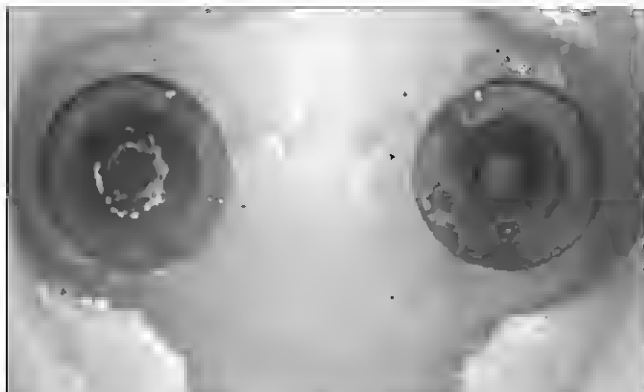


# ENGINE - KAWASAKI (FH661V, FH721V) DIAGNOSTICS

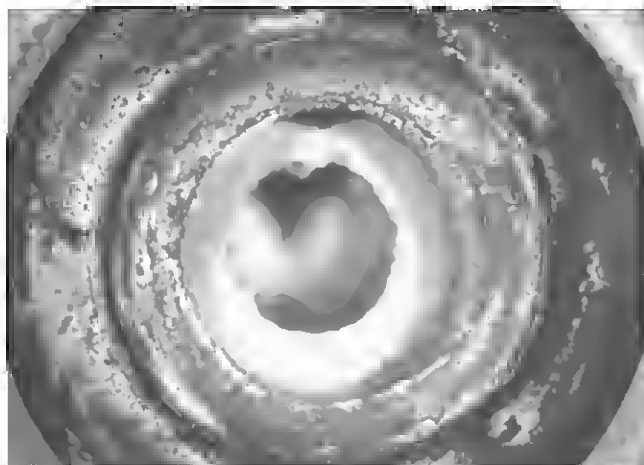
## Carburetor Diagnostic Inspection

Inspect the carburetor float bowl and passages for debris, varnish buildup, and corrosion.

Check for damaged parts or parts installed incorrectly.



MX47332 and MX47333



MX47469

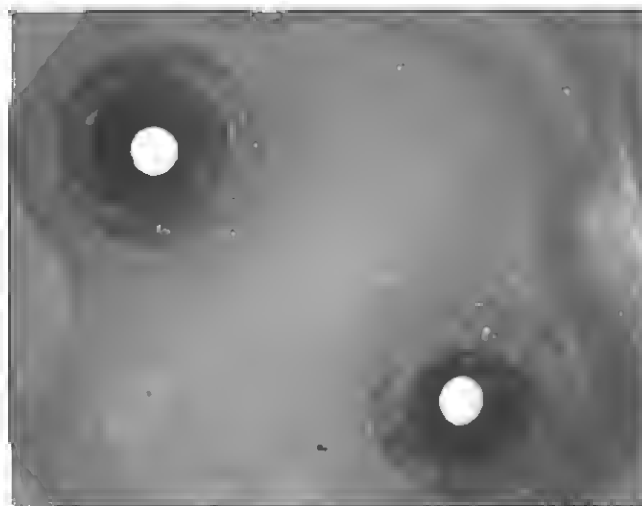
1. White corrosion or green corrosion is usually caused by water. Water can combine with other chemicals and create acids and salts which accelerate corrosion. Water can be absorbed by ethanol, so the more ethanol, the worse the problem.

Extreme corrosion may involve salt water. Sometimes the exterior of the carburetor will also be corroded. The location of the machine (such as coastal regions) will provide additional clues to the cause of corrosion.



MX47472

2. Red or brown corrosion is usually caused by an iron or steel part that has corroded. Look at steel fuel inlet fittings, steel parts in fuel filters. It could also indicate some other contaminant in the fuel. Some microbial contaminations can be reddish.



MX47471

3. Brown varnish and gum deposits are generally from old degraded fuel. It usually has a distinctive "old varnish" smell. Look for it in areas that would be adversely affected, such as fuel and air passages, needles and seats.

4. Damage from excessive ethanol, methanol, MTBE, ethers, will usually be seen as damage to rubber parts. Look for cracks, swelling, shrinking, loss of elasticity, takes a permanent set or becomes hard or brittle. Look for plastic damaged parts.

5. Debris stuck in small orifices and other critical areas. Look in jets, fuel and air passages, fuel inlet needle and seat, idle mixture adjustment needles and seats, idle progression holes, fuel shutoff solenoid plunger, etc. The

# ENGINE - KAWASAKI (FH661V, FH721V) GENERAL INFORMATION

material of the debris can help determine the source. Look for the following:

- a. Cellulose and other organic fibers are usually grass debris that was ingested by the engine air intake or fuel system, they could also be fibers from the fuel filter element.
  - b. Sand can come from ingesting dirt by the engine air intake system or fuel system or from unclean manufacturing and parts packaging.
  - c. Metallic particles such as aluminum, brass, and iron chips typically come from the manufacturing process and unclean parts packaging and assembly areas.
  - d. Plastic particles usually come from manufacturing processes such as plastic molding, welding, adhesive (epoxy used in fuel filters), and unclean part packaging and assembly areas.
  - e. Rubber particles usually come from the fuel lines, fuel pump diaphragms, or internal parts, and unclean part packaging and assembly areas.
  - f. Cardboard particles and fibers usually come from parts packaging and unclean assembly areas.
  - g. Hair fibers usually come from unclean parts packaging and assembly areas.
6. Wrong parts, such as wrong size jet or left and right jets switched.
  7. Damaged parts, such as jets having tool marks that affect the fuel flow, cracked plastic parts, etc.
  8. Defective parts such as porosity in castings, excessive flash on castings or molded parts, defective welds or adhesive joints, throttle shafts that fit too tight or too loose, throttle plates out of alignment or not matched to bores, etc. Defective machining is difficult to diagnose unless it's obvious.

## General Information

### Cleaning Carburetors

Debris, corrosion, rust, or varnish can build up in the internal air/fuel passages. Many times the contamination is located in an area of the carburetor that is not visible. In most cases proper cleaning can resolve these issues.

Carburetors and carburetor components can be cleaned by using one of several types of commercial cleaning methods: aerosol sprays, caustic dip tanks, and ultrasonic cleaners.

**Note: Some cleaning chemicals may be flammable and have toxic fumes. Always follow the chemical manufacturer's recommendations. Always wear personal protection gear such as safety glasses**

**protective gloves and work in a well ventilated area. Do not use drill or hard wire to clean carburetor passage ways.**

### Cleaning Procedure

Always follow the solvent manufacturer's recommendations for material compatibility because some solvents may attack metal, plastic or rubber components.

1. Clean debris off the outside of the carburetor before disassembly.
2. Completely disassemble the carburetor per the instructions in the Technical Manual and visually inspect.
3. Determine if carburetor is repairable, excessive corrosion may determine this is not practical.
4. If repairable, clean any remaining dirt and old gaskets from the carburetor.

The preferred method of cleaning is to use an ultrasonic cleaner.

**Important: Avoid Damage!** Wires and metal instruments should not be used. Light damage or deposits on the surface of the float valve seat can be removed using a cotton swab with a mild abrasive such as toothpaste or 800 grit lapping compound.

### Carburetor Assembly

When the carburetor is ready for assembly, lay out all the necessary components on a clean surface. Be aware that even clean shop rags may contain dirt and metal shavings. Assemble the carburetor in accordance with the instructions in the Technical Manual. Keep the following in mind:

- Check the throttle shaft for excessive play or movement and any signs of binding.
- Never use oil on the throttle shaft because it attracts dirt which can cause premature wear of the throttle shaft seals.
- If the throttle shaft was removed use new screws and follow the service manual torque specifications.
- Always check the float and float valve for binding with the float valve installed in its proper position.
- Replacement of all gaskets and seals is necessary when servicing any carburetor.
- Inspect the carburetor insulator for damage and replace if necessary. Be sure to install the insulator using the correct orientation.
- Clean and flush the complete fuel system.
- Fuel lines must be replaced if they are brittle, cracked, excessively soft or damaged.
- Replace the fuel filter and air filter after cleaning the

# ENGINE - KAWASAKI (FH661V, FH721V) GENERAL INFORMATION

carburetor.

## Cleaning Methods

### Ultrasonic Cleaning Systems

Ultrasonic cleaners use environmentally friendly cleaning solution and sound waves to penetrate deep into carburetor passages. Heating the solution is an option on ultrasonic cleaners that significantly increases the effectiveness of the system. Ultrasonic cleaner systems work by creating sound wave pulses that are transmitted through a cleaning solution. Manufacturers of ultrasonic cleaners claim the pulses create small bubbles that loosen and pulverizes contaminants. Select a chemical solution that is designed specifically for carburetor cleaning.

Generally, chemicals will need to be diluted with water prior to use. When choosing a chemical, consider dilution rates to help determine which chemical is the most cost effective. Consider disposal of cleaning solution before ordering chemicals. Check with local authorities on recommended disposal methods before disposing of any cleaning solution. Ultrasonic cleaners come in many sizes. Most 1.5-2 gallon tanks will be sufficient for carburetors used by John Deere gas engines.

If an Ultrasonic Cleaner is used, place carburetor in and run for 30 minutes at 110 F in the proper solution mix. If the solution is too strong or the carburetor is left in the cleaner for too long, the aluminum body will have a residue on the surface from the aluminum oxidizing.



**Caution: Avoid Injury! Compressed air can cause debris to fly a long distance.**

- Clear work area of bystanders.
- Wear eye protection when using compressed air for cleaning purposes.
- Reduce compressed air pressure to 210 kPa (30 psi).

Rinse the parts in water and dry with compressed air (up to 30 psi).

Wash off and blow ports out in carburetor body/ fuel transfer tubes / and discharge port. Blow compressed air through carburetor passages in the opposite direction of the air/fuel flow (into the smallest passages to flush debris out of the larger passages). This will prevent debris lodging in difficult to clean areas.

### Aerosol Cleaner

Personal safety, environmental concerns and cleaning effectiveness make this method the least desirable. This method can be used on carburetor components that may be damaged by caustic cleaners (rubber seals or other

non-metallic components). When cleaning with aerosol sprays, it is always best to spray in the opposite direction of the air/fuel circuit (into the smallest passages to flush debris out of the larger passages). This will prevent debris lodging in difficult to clean areas.



**Caution: Avoid Injury! Vapors from solvents can be explosive and flammable. Follow the instructions on the container label for safe use of the solvent:**

- Work in a well-ventilated area.
- Wear protective clothing when handling solvent.
- Do not smoke while handling solvents.
- Keep solvent away from flames or sparks.

### Caustic Dip Tanks

Caustic dip tanks use aggressive chemicals to dissolve carbon based contamination. This method is effective for most carburetor cleaning needs.

Rotating the parts in the tank will ensure the cleaning solution flushes out any air pockets left in the passages. Follow the recommendation on the cleaner for submersion times. Disadvantages of the caustic dip tanks are that some carburetor parts may be damaged if left in solution too long.

Personal safety and chemical disposal are additional concerns. Because the chemical is caustic, exposure may cause injury or death. Disposal of used solution can be difficult because most cleaners are considered hazardous waste.

### Fuel

Use only fuels recommended in Operator's Manual:

Use regular grade unleaded fuel with an octane rating of 87 octane or higher. Fuel blends containing up to 10% ethanol or up to 15% MTBE reformulated fuel are acceptable. DO NOT use fuels with more than 10% ethanol (i.e. E85 should not be used because it is 85% ethanol and 15% gasoline) or fuels with more than 15% MTBE reformulated fuel as these products will damage engine and or fuel system. Do not use fuel or additives containing methanol as engine damage can occur.

All fuel today is formulated for the automotive industry. Fuel is "blended" differently for winter and summer use; regardless of where you are. "Winter" fuel is blended for improved vaporization in colder temperatures. Using left over "Winter" fuel in warmer Spring/Summer temperatures will likely cause vapor locking and surging. Newer carburetors on current production machines have less

# ENGINE - KAWASAKI (FH661V, FH721V) TESTS AND ADJUSTMENTS

tolerance for poor quality fuel because of the tighter specifications required to meet EPA certification.

## Fuel Storage

Since it is difficult to know what type of fuel is in different areas; it is best to handle and maintain fuel as outlined below:

1. Deteriorated/stale fuel causes gum and varnish. This creates deposits on engine valves and in carburetor jets and passages. This is what causes most of the performance problems.
2. Oxygenated (or blended) fuels can deteriorate faster and require more specific storage and usage procedures.
3. The translucent fuel tanks on some model tractors allow a certain amount of sunlight through the tank. This can accelerate the deterioration of the fuel.



**Caution: Avoid Injury! Fuel stabilizer is a hazardous chemical and can be harmful or fatal if swallowed. Do not take internally. Avoid contact with eyes. Avoid breathing the chemical vapors.**

**Read safety instructions on stabilizer container label before using.**

**Fuel stabilizer contains 2,6-di-tert-butylphenol (128-39-2) and aliphatic petroleum distillate (64742-47-8). In case of emergency, contact a physician immediately and call 1-800-424-9300 for material safety information.**

**Note: There is no fuel stabilizer made that will "restore" stale fuel. Fill tanks with fresh, stabilized fuel.**

4. Use fuel from a major name brand supplier. At the same time, add an appropriate amount of Fuel Stabilizer (such as TY25808). Do this when you add fresh fuel to your tank.
5. If engine performance problems arise, try another brand of fuel. You may have to try several different sources.
6. Any fuel over 30 days old is considered "stale".
  - For 2-cycle equipment, purchase as small a quantity of fuel as feasible. If there is doubt about how long the fuel may be stored, add stabilizer right away. JOHN DEERE PREMIUM EXACT MIX 2-Cycle Oil (UP08127) already has a fuel stabilizer added to the oil. When using this oil fuel mix, it will stay fresh for up to 30 days. If storing a 2-cycle powered unit for more than 3 weeks, it is recommended to run the fuel out of the unit.

## Tests and Adjustments

### Throttle Cable Check and Adjustment

#### Reason:

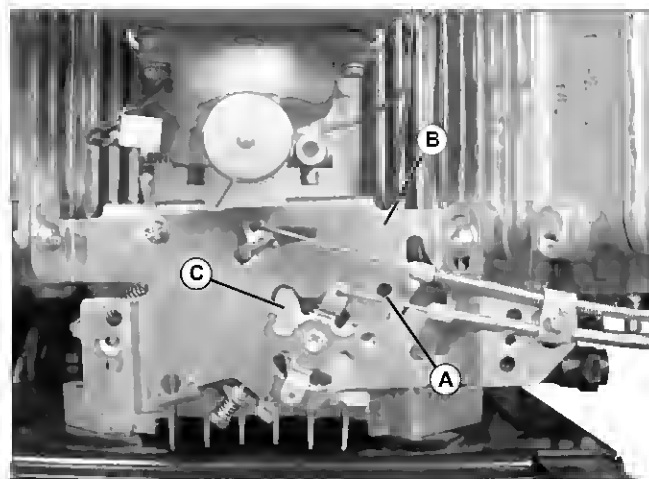
To make sure the throttle control arm has the proper amount of travel for maximum engine performance.

#### Equipment:

- 6 mm (1/4-in.) Drill Bit

#### Check Procedure:

1. Park machine safely. See "Park Machine Safely" in the Safety section.
2. Move throttle control lever from SLOW idle to FAST idle position.



MX36429

3. Check hole alignment (A) in control panel (B) and throttle arm (C). They MUST be in visual alignment.
4. Move throttle control lever into SLOW idle position, then back into FAST idle position. Again, holes in control panel and throttle arm MUST be aligned.

#### Results:

- If holes align throttle cable adjustment is OK.
- If holes DO NOT align, perform "Adjustment Procedure".

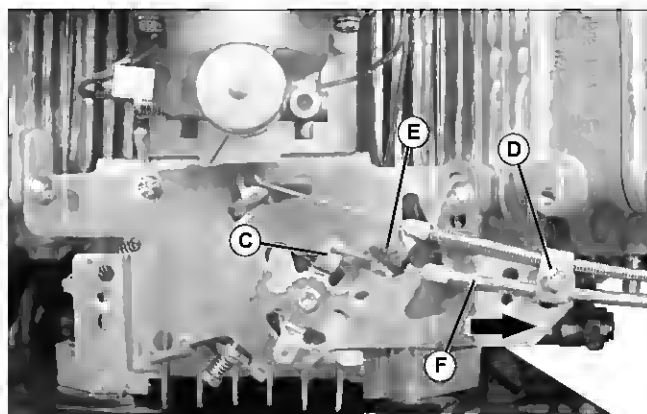
#### Adjustment Procedure:



**Caution: Avoid Injury! Engine components are HOT. Do not touch, exhaust pipe or muffler while making adjustments.**

1. Move throttle control lever to FAST.

# ENGINE - KAWASAKI (FH661V, FH721V) TESTS AND ADJUSTMENTS



MX36430

2. Loosen cable retainer screw (D).
3. Move throttle arm (C) and throttle cable (F) to align holes in control panel and throttle control plate. Insert a 6 mm (1/4 in.) bolt or drill bit (E) through holes to keep throttle arm from moving. Be sure bolt or drill bit is perpendicular to the control panel.
4. Make sure throttle control lever on dash is still in FAST position. Tighten retaining screw (D).
5. Remove bolt or drill bit.
6. Repeat "Check Procedure".
7. Move throttle control lever through full range to be sure linkage is not binding.

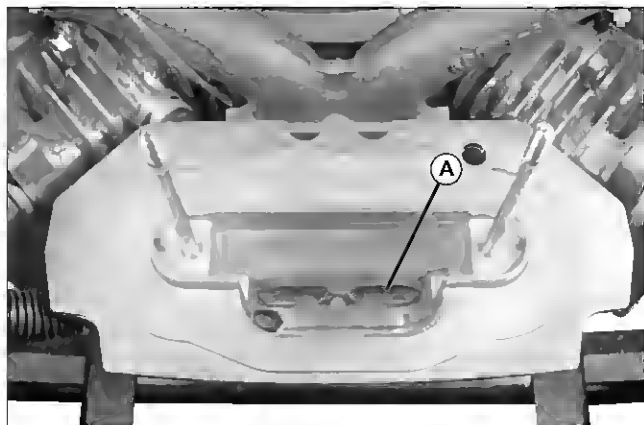
## Choke Plate Check and Adjustment

### Reason:

To make sure the choke plate is fully open when the choke control lever is in the OFF position.

### Check Procedure:

1. Park machine safely. See "Park Machine Safely" in the Safety section.
2. Unscrew and remove air cleaner cover and air filter.



MX36431

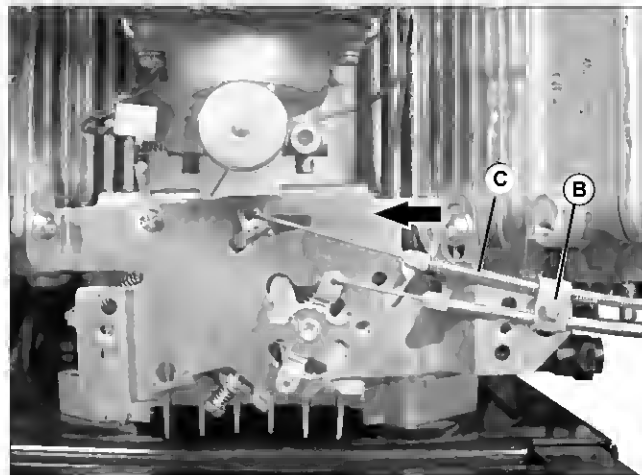
3. Move the choke lever back and forth between the ON and OFF position while looking into the carburetor throat to watch the choke valve plate (A) close and open.
4. Watch to see that the choke valve plate contacts the base of the carburetor throat in the closed position (choke ON left side), and is in a horizontal position in the open position (choke OFF right side).

### Results:

- If the choke valve plate does not move to either the full open or full closed position, perform "Adjustment procedure".

### Adjustment Procedure:

1. Park machine safely. See "Park Machine Safely" in the Safety section.
2. Move choke control lever to OFF (open) position.



MX36429

3. Loosen cable retainer screw (B).
4. Push choke cable (C) out (arrow) until the choke plate is full open and tighten retainer screw.
5. Repeat "Check Procedure".
6. Move choke lever through full range to be sure linkage is not binding.

# ENGINE - KAWASAKI (FH661V, FH721V) TESTS AND ADJUSTMENTS

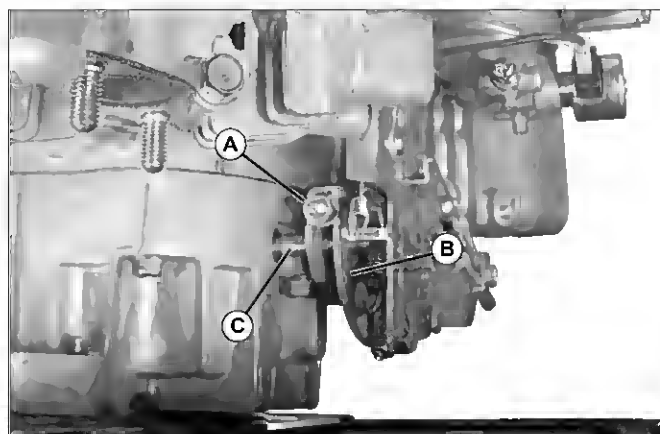
## Governor Adjustment

### Reason:

To make the governor shaft contact the flyweight plunger when the engine is stopped.

### Procedure:

1. Park machine safely. See "Park Machine Safely" in the Safety section.
2. Move throttle control lever to FAST position.



MX36432

**Picture Note:** Exhaust system removed for clarity.

3. Loosen nut (A).
4. Hold governor arm (B) in the fully counterclockwise position.
5. Using a small pin, rotate shaft (C) counterclockwise as far as it will go.
6. Hold governor shaft and governor arm in place and tighten nut to specification.
7. Move throttle control lever through full range to be sure linkage is not binding.

### Specification:

**Torque** ..... 7.8 N•m (69 lb-in.)

## Slow Idle Speed Adjustment

### Reason:

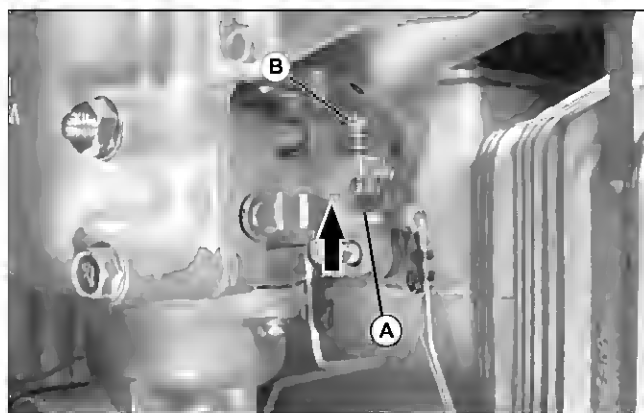
To set engine slow idle rpm.

### Equipment:

- JTO7270 Digital Pulse Tachometer, or
- JT05719 Photo Tachometer

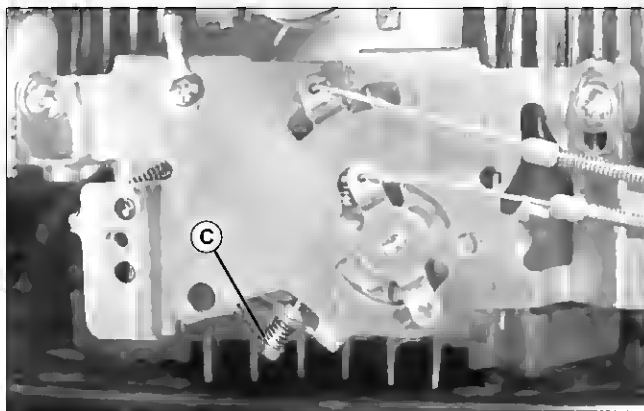
### Procedure:

1. Park machine safely. See "Park Machine Safely" in the Safety section.
2. If using photo tachometer, put reflective tape on blower housing screen.
3. Start and run engine at MEDIUM idle for five minutes.
4. Move throttle control lever to SLOW idle position.
5. Use tachometer to check engine rpm.



MX36433

6. Hold throttle lever so that tab (A) is against SLOW idle stop screw (B).
7. Turn SLOW idle stop screw until engine rpm is set at 1450 rpm.



MX36433

8. Release the throttle lever and check the governed SLOW idle rpm.

# ENGINE - KAWASAKI (FH661V, FH721V) TESTS AND ADJUSTMENTS

**Note:** Be sure idle stop screw on the control panel is in contact with throttle arm when making adjustments.

9. Adjust idle stop screw (C) on the control plate to obtain specified governed slow idle.

## Specification:

Slow Idle .....  $1850 \pm 100$  rpm

## Fast Idle Speed Adjustment

### Reason:

To set engine fast idle speed setting.

### Equipment:

- 6 mm (1/4 in.) Drill Bit
- JTO7270 Digital Pulse Tachometer, or
- JT05719 Photo Tachometer

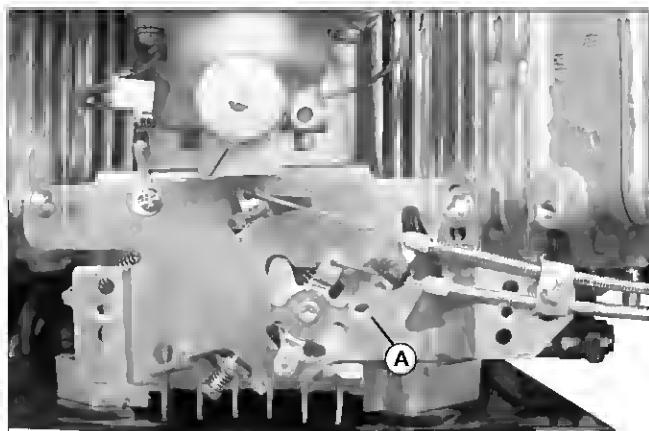
### Procedure:

1. Park machine safely. See "Park Machine Safely" in the Safety section.
2. If using photo tachometer, put reflective tape on blower housing screen.
3. Start and run engine at MEDIUM idle for five minutes.



**Caution: Avoid Injury! Engine will be HOT. Be careful not to burn hands.**

4. Move throttle control lever to FAST idle position.

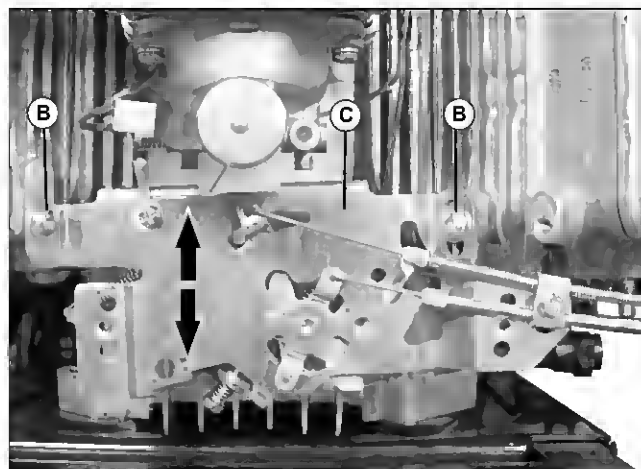


MX36430

5. Align holes in throttle arm and throttle control bracket (A). Place a 6 mm (1/4-in.) drill bit through holes to keep the throttle control arm from moving. Be sure drill bit is perpendicular to the throttle control panel.
6. Use tachometer to check engine rpm. Fast idle speed setting should be to specification.

### Results:

- If fast idle speed does not meet the specifications:



MX36429

1. Loosen cap screws (B).
2. Move throttle control panel (C) up to increase rpm or down to decrease rpm.
3. Hold the throttle control panel and tighten cap screws to specification.
4. Remove the drill bit.

### Specification:

Fast Idle Speed .....  $3350 \pm 100$  rpm  
Control Panel Screw Torque ..... 5.9 N·m (52 lb-in.)

## Valve Clearance Check and Adjustment

### Reason:

To obtain the proper valve clearance that is critical for the valves to seat properly.

### Equipment:

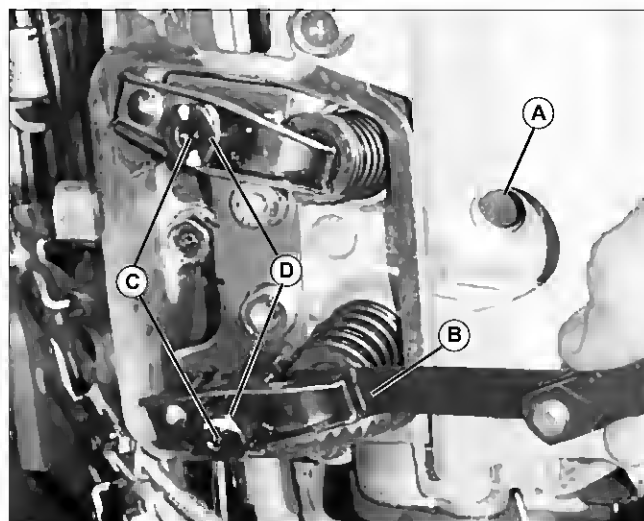
- Feeler Gauge

### Procedure:

**Important: Avoid Damage! Perform valve clearance check or adjustment when engine is cold.**

1. Park machine safely. See "Park Machine Safely" in the Safety section.
2. Allow engine to cool.
3. Remove and ground both spark plug leads. Remove spark plugs.
4. Remove valve cover.

# ENGINE - KAWASAKI (FH661V, FH721V) TESTS AND ADJUSTMENTS



MX37643

5. Turn crankshaft until piston, visible in spark plug hole (A), is at TDC (top dead center) of the compression stroke (both intake and exhaust valves will be closed).
6. Use a feeler gauge (B) to measure valve clearance. Valve clearance should be within specification.

## Results:

1. If valve clearance does not meet specification, loosen lock screws (C). Turn adjusting nut (D) to adjust valve clearance to specifications.
2. Hold adjusting nut and tighten lock screw to specification. Check clearance again.

## Specifications:

Valve Clearance (Intake and Exhaust) (Cold) . . . 0.075 - 0.125 mm (0.003 - 0.005 in.)

Lock Screw Torque . . . . . 6.9 N•m (61 lb-in.)

Valve Cover Cap Screw Torque . . . . 5.9 N•m (52 lb-in.)

Spark Plug Torque . . . . . 25 N•m (221 lb-in.)

## Cylinder Leak-Down Test

### Reason:

To determine if compression pressure is leaking from cylinder.

### Test Equipment:

- JTO3502 Compression Leakdown Tester

### Procedure:

1. Start engine. Run for 5 minutes to bring it up to normal operating temperature.
2. Park machine safely. See "Park Machine Safely" in the Safety section.



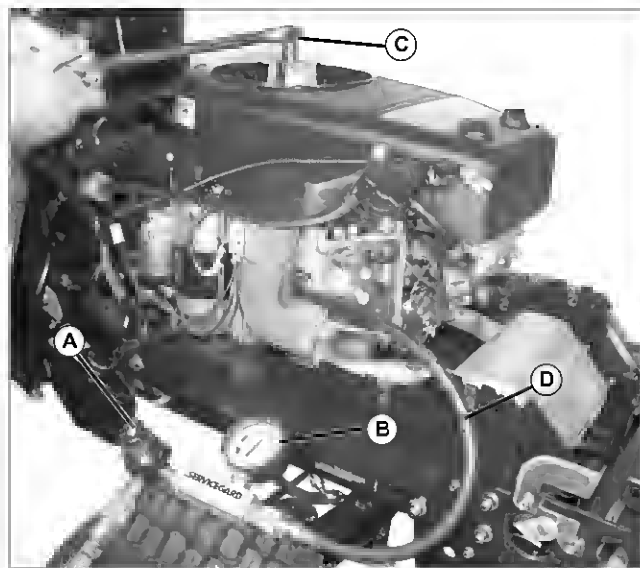
**Caution: Avoid Injury! Engine components are HOT. Be careful not to touch, especially the exhaust pipe or muffler while making adjustments. Wear protective eye glasses and clothing.**

3. Remove spark plugs.
4. Remove rocker arm covers.

**Note: The crankshaft must be held with the piston just slightly past TDC to seal the combustion chamber and eliminate the chance of rotation. Screw the adapter hose (D) into the spark plug hole, but do not attach it to the tester at this time.**

5. Turn crankshaft until piston, visible in spark plug hole, is at TDC of the compression stroke (both intake and exhaust valves will be closed).

**Note: The air supply must have enough supply pressure to calibrate the tester, usually 585 - 655 kPa (85 - 95 psi).**



MX37442

6. Connect tester port to an air source.

**Note: Air leaks at any of the connections or fittings of the tester will affect the accuracy of the test.**

7. Pull back the locking ring and slowly rotate the regulator adjustment knob (A) until the gauge needle is in the SET range of the gauge (B). Push the locking ring towards the tester to lock knob in position.





**Caution: Avoid Injury!** Injury can occur if the crankshaft is not locked in position. The air source can create a rotational force of up to (81 N•m) 60 lb-ft if the crankshaft is not locked with the piston slightly past top dead center.

8. Have an assistant hold the crankshaft in position with socket and breaker bar (C). Connect the adapter hose (D) to the tester, and record the needle position.

**Note:** A small amount of air escaping from the crankcase breather is normal. If a high flow of air is leaking from the exhaust or carburetor areas, make sure that piston is just slightly past TDC of the compression stroke.

9. Observe reading on gauge. Listen for air leaking from the cylinder head gasket, carburetor, exhaust system and either the crankcase breather or oil fill/ dipstick tube.

## Results:

- Gauge reading in the Green (low) area indicates good compression. (Less than 25% leakage is considered normal).
- Gauge reading in the Yellow (Moderate) area indicates borderline compression. The engine is still usable but an overhaul or replacement should be considered.
- Gauge reading in the Red (High) area indicates excessive compression loss. Engine reconditioning or replacement is necessary.
- Check air escaping from muffler, air cleaner or oil fill opening.
- Excessive air escaping from the crankcase breather indicates worn piston rings or cylinder wall.
- Air escaping from the carburetor indicates a worn intake valve or seat.
- Air escaping from the exhaust pipe indicates a worn exhaust valve or seat.
- Repeat test on other cylinder.

## Cylinder Compression Pressure Test

### Reason:

To determine the condition of the pistons, rings, cylinder walls, and valves.

### Test Equipment:

- JDM59 Compression Gauge

### Procedure:

1. Valve clearance must be adjusted properly before doing a compression test.
2. Run engine for five minutes to bring engine to operating temperature.
3. Park machine safely. See "Park Machine Safely" in the Safety section.
4. Remove spark plugs.
5. Install JDM59 compression gauge in one spark plug hole.
6. Ground high tension leads.
7. Move throttle control lever to FAST idle position.
8. Check that choke is fully open and that air filter is clean.

**Important: Avoid Damage! DO NOT overheat starting motor during test. Starter duty cycle is 5 seconds ON, 10 seconds OFF.**

9. Crank engine for three to five compression strokes.
10. Record pressure reading.
11. Repeat test with other cylinder.

### Specifications:

**Minimum Compression . . . . . 390 kPa (57 psi)**

### Results:

**Note:** Specification is for an engine that has sufficient time to allow rings to fully seat. Compression that is lower than specifications on low hour machines (but relatively equal on both cylinders) probably does not indicate a problem.

- If above specification, adjust valves and check fuel and air intake systems. Check exhaust for restriction.
- If below specification, squirt clean engine oil into cylinder and repeat test.
- If compression pressure DOES NOT increase after retest; check for leaking valves, valve seats, or cylinder head gaskets.
- If compression pressure INCREASES after retest; check rings, pistons, and cylinder bores for broken rings,

# ENGINE - KAWASAKI (FH661V, FH721V) TESTS AND ADJUSTMENTS

scoring, wear or damage. Replace as necessary.

## Crankcase Vacuum Test

### Reason:

To measure the amount of crankcase vacuum, which ensures the crankcase is not pressurized. A pressurized crankcase will force oil leakage past the seals and gaskets and affect fuel pump operation.

### Test equipment:

JT03503 Vacuum Gauge

### Procedure:

**Important: Avoid Damage! DO NOT make connection between test gauge and rubber plug BEFORE engine is running at FAST idle or gauge damage may result**

1. Park machine safely. See "Park Machine Safely" in the Safety section.
2. Remove dipstick.
3. Install appropriate size ported rubber plug in dipstick tube.
4. Insert barbed fitting into clear line and attach to gauge.
5. Hold finger over rubber plug hole to keep oil from spraying out. Start engine and run at FAST idle.
6. Connect gauge, clear line, and barbed fitting to rubber plug.
7. Record crankcase vacuum reading. Gauge should show a minimum vacuum of **25 cm (10 in.)** of water movement.

**Important: Avoid Damage! After test reading is made, DO disconnect test gauge WHILE engine is running at FAST idle to prevent damage to gauge.**

8. Disconnect barbed fitting, clear line, and gauge from rubber plug while engine is running at FAST idle. Hold finger over rubber plug hole to keep oil from spraying out.
9. Move throttle to SLOW idle and turn engine OFF.
10. Remove rubber plug and install dipstick.

### Results:

If crankcase vacuum is BELOW specification, check the following:

- Breather port is obstructed.
- Condition of breather valve.
- Rings, piston, and cylinder bore for wear or damage.

## Engine Oil Pressure Test

### Reason:

To verify if the engine has enough oil pressure to lubricate internal components.

### Test Equipment:

- JT03344 Pressure Gauge Assembly
- JT03017 Hose Assembly
- JT03349 Connector

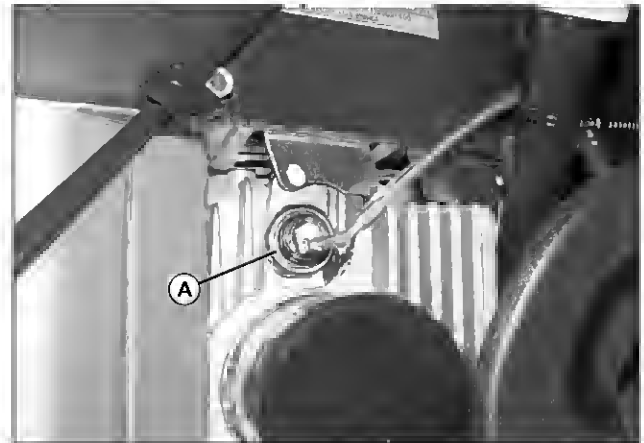
### Procedure:

1. Park machine safely. See "Park Machine Safely" in the Safety section.



**Caution: Avoid Injury! Engine components are HOT. Be careful not to touch, especially the exhaust pipe or muffler while making adjustments. Wear protective eye glasses and clothing.**

2. Allow engine to cool.
3. Check engine oil level, bring level to full mark.



MX36441

4. Remove oil pressure switch (A).
5. Install JT03349 Connector.
6. Connect JT03017 hose assembly and JT03344 pressure gauge assembly.
7. Monitor oil pressure while cranking engine. If no oil pressure is present, discontinue cranking engine. Determine and correct cause before running engine.

**Important: Avoid Damage! If pressure reading is below 69 kPa (10 psi), STOP ENGINE IMMEDIATELY and determine cause.**

8. Start and run engine at MEDIUM idle for five minutes to

# ENGINE - KAWASAKI (FH661V, FH721V) TESTS AND ADJUSTMENTS

heat engine oil to normal operating temperature.

9. Run engine at fast idle and check oil pressure.

**Note:** Use *silicon sealer on switch threads*.

10. Remove test equipment and install oil pressure switch. Tighten switch to specification.

## Results:

If oil pressure is BELOW specifications, inspect or replace the following:

- Oil filter plugged.
- Oil pressure relief valve for broken or worn spring.
- Oil pressure relief valve for stuck or damaged valve.
- Worn or damaged oil pump.
- Oil pump suction screen or oil passages plugged.
- Excessive wear of connecting rod and main bearing journals.

## Specifications:

**Oil Pressure Minimum** . . . . . 69 kPa (10 psi)

**Oil Pressure at Fast Idle** . . . . 240 - 310 kPa (35 - 45 psi)

**Switch Torque** . . . . . 9.8 N•m (87 lb-in.)

## Fuel Pump Test

### Reason:

To check condition of fuel pump and determine fuel pressure.

### Test Equipment:

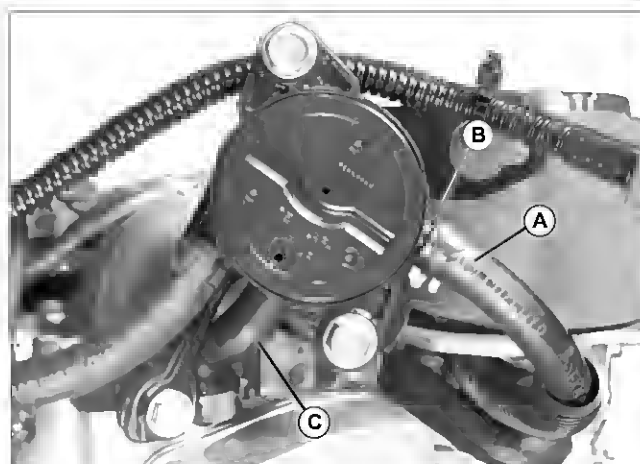
- JDG356 Pressure Gauge
- Graduated Container

### Procedure:

1. Park machine safely. See "Park Machine Safely" in the Safety section.



**Caution: Avoid Injury!** Gasoline is extremely flammable. DO NOT SMOKE. Always work in a well ventilated area away from open flame or spark producing equipment; this includes equipment that utilizes pilot lights.



MX36435

2. Disconnect and plug fuel pump outlet hose (A).
3. Connect JDG356 pressure gauge to fuel pump outlet (B).
4. Start and run engine at fast idle for 15 seconds, then record pressure reading.
5. Stop engine.
6. Remove pressure gauge from fuel pump outlet and connect a length of hose long enough to reach into a graduated container.
7. Start and run engine at fast idle for 15 seconds, then stop the engine and record container measurement.

## Results:

If fuel pump pressure or flow does not meet the specifications, check the following:

- Fuel lines, vacuum line (C), fuel filter and fuel tank cap for restrictions.
- Check fuel pump vent holes for obstruction.
- Check crankcase vacuum.
- Replace fuel pump.

## Specifications:

**Minimum Fuel Pressure** . . . . . 6.12 kPa (0.90 psi)

**Minimum Fuel Flow** . . . . . 65 mL (2.2 oz)/15 seconds

# ENGINE - KAWASAKI (FH661V, FH721V) TESTS AND ADJUSTMENTS

## Spark Test

### Reason:

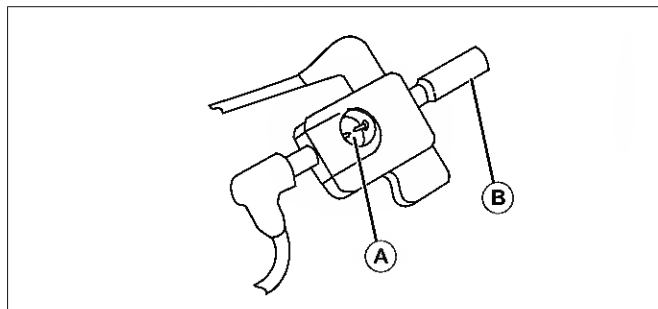
Check overall condition of ignition system.

### Test Equipment:

- D-05351ST Spark Tester

### Procedure:

1. Park machine safely. See "Park Machine Safely" in the Safety section.



MIF

2. Remove high tension lead from spark plug.
3. Connect D-05351ST spark tester to spark plug.
4. Connect high tension lead to spark tester.

**Important: Avoid Damage! Do not adjust spark tester gap beyond 5.0 mm (0.200 in.) (5 turns), as damage to ignition components could occur.**

5. Adjust spark tester gap (A) to 4.2 mm (0.166 in.) (4 turns) with screw (B).
6. Move key switch to RUN position.
7. Spin engine with starter and watch spark at spark tester. If engine will start, watch spark with engine running. A steady, strong, blue spark should be observed.
8. Repeat test on other cylinder.

### Results:

- If spark is weak, or no spark is present, install a new spark plug and repeat test.
- If spark is still weak, or no spark is present, run tests on individual components to find the cause of the malfunction.

## Spark Plug Gap Adjustment

### Equipment:

- Feeler Gauge, or
- Wire Gauge

### Procedure:

1. Park machine safely. See "Park Machine Safely" in the Safety section.



**Caution: Avoid Injury! Engine components may be HOT. Be careful not to touch, especially the exhaust pipe or muffler while making adjustments.**

2. Remove spark plugs.
3. Inspect each spark plug for cracked porcelain and pitted or damaged electrodes.
4. Check spark plug gap using a feeler or wire gauge. Set gap to specification.
5. Install and tighten spark plugs to specification.

### Specifications:

Gap ..... 0.76 mm (0.030 in.)

Torque ..... 25 N·m (221 lb-in.)

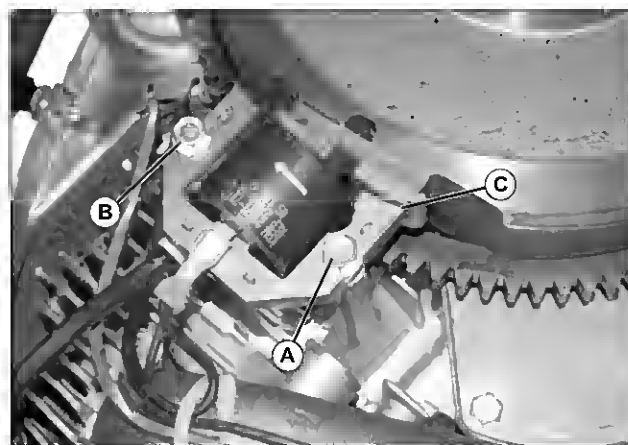
## Ignition Coil Air Gap Adjustment

### Equipment:

- Feeler Gauge

### Procedure:

1. Center flywheel magnet under one armature leg and coil.



MX36428

2. Insert a 0.30 mm (0.012 in.) feeler gauge between flywheel and armature (C).

# ENGINE - KAWASAKI (FH661V, FH721V) REPAIR

3. Loosen screws (A) and (B) and push armature against feeler gauge. Tighten cap screw (A).
4. Turn flywheel to center flywheel magnet under coil and second armature leg.
5. Repeat setting air gap for second armature. Tighten cap screw (B).
6. Rotate flywheel fully around and check both air gap measurements.
7. Tighten cap screws to specification.

## Specifications:

**Ignition Coil Air Gap . . . . . 0.25 - 0.40 mm (0.010 - 0.016 in.)**

**Cap Screw Torque . . . . . 5.9 N•m (52 lb-in.)**

## Repair

### Throttle Control Lever and Cable

#### Removal and Installation:

1. Remove dash panel.
2. Disconnect throttle control cable at engine. Remove throttle control cable assembly.
3. Replace throttle control lever or cable as required.

**Installation is done in the reverse order of removal.**

- Adjust throttle control cable and choke plate. See "Throttle Cable Check and Adjustment" on page 108 and "Choke Plate Check and Adjustment" on page 109.

### Muffler Removal and Installation

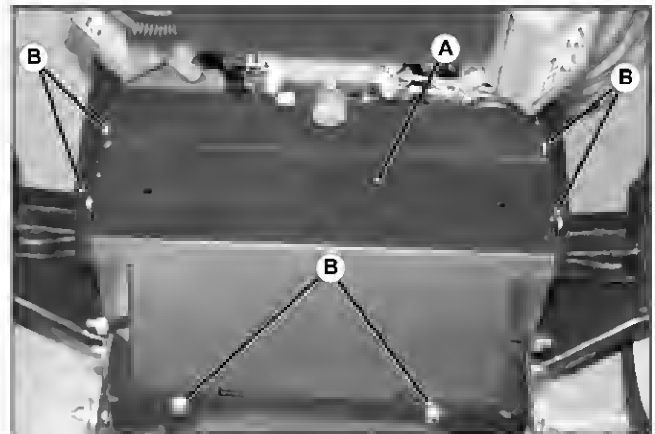
#### Removal:

1. Park machine safely. See "Park Machine Safely" in the Safety section.



**Caution: Avoid Injury! To prevent possible burns, allow engine to cool before removing heat shields and muffler**

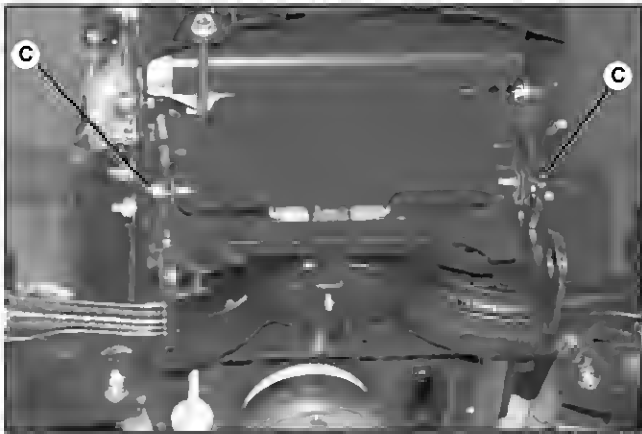
2. Disconnect negative (-) cable from battery.



MX37059

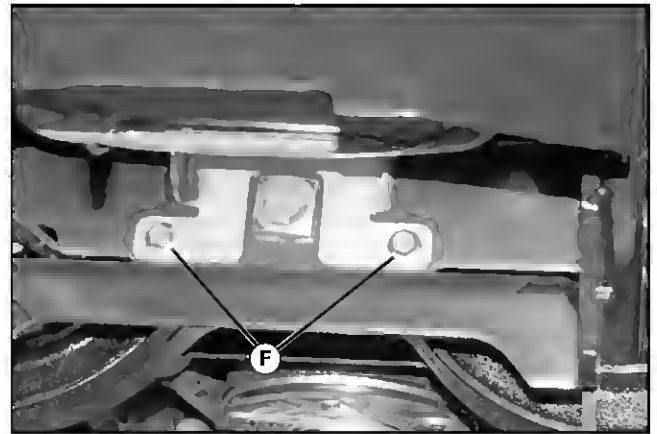
3. Remove six screws (B) securing top heat shield (A) to frame.

## ENGINE - KAWASAKI (FH661V, FH721V) REPAIR



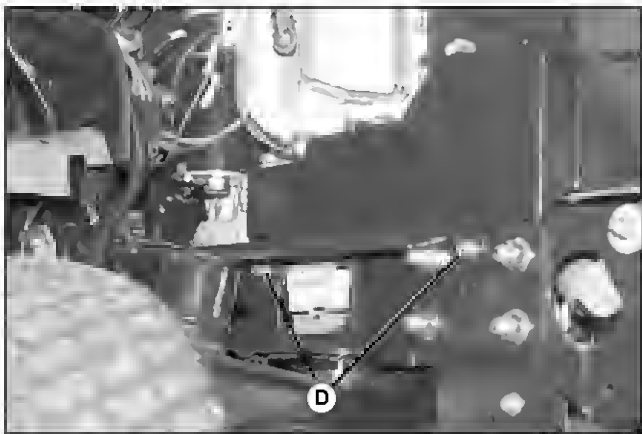
MX37062

4. Remove two screws (C) securing lower heat shield to frame.



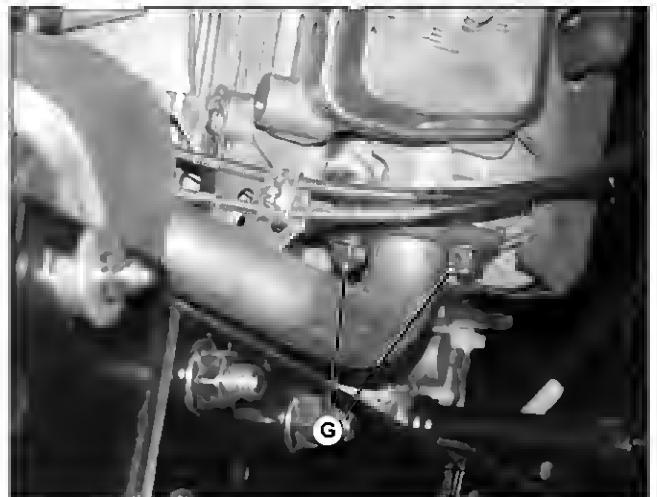
MX37061

7. Remove two screws (F) securing muffler mounting bracket to frame.



MX37064

5. Remove two screws (D) securing right side heat shield to frame.



MX37065

**Picture Note:** Left side shown, right side is same.

8. Remove screws (G) securing exhaust pipes to engine.
9. Remove muffler and gaskets.

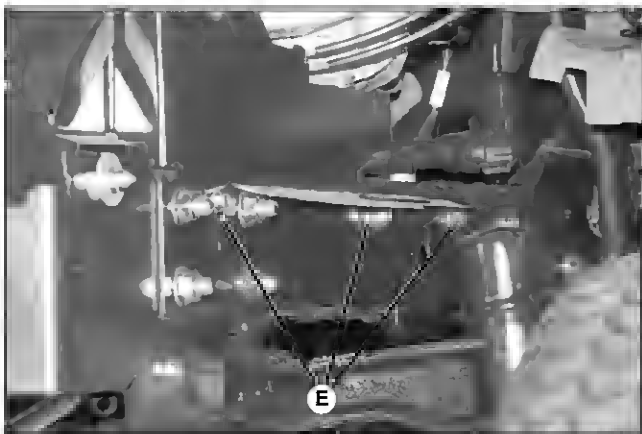
### Installation:

Installation is done in the reverse order of removal.

- Use new gasket for installation.

### Specifications:

**Muffler Nut Torque** . . . . . 15 N•m (133 lb-in.)



MX37063

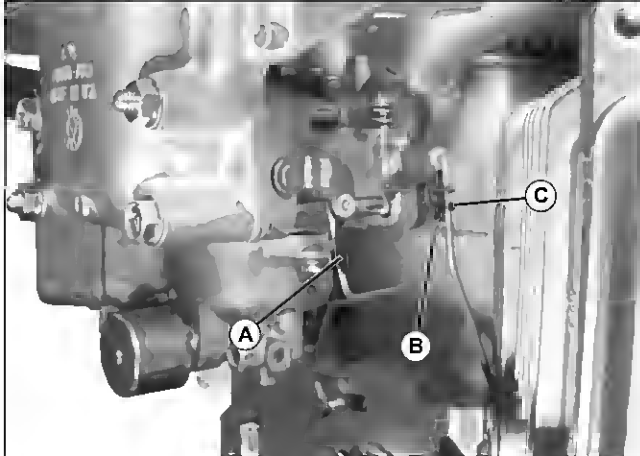
6. Remove three screws (E) securing left side heat shield to frame.

# ENGINE - KAWASAKI (FH661V, FH721V) REPAIR

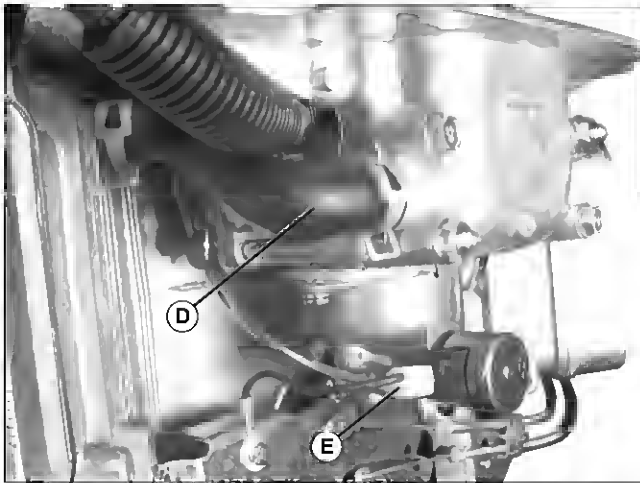
## Carburetor Removal and Installation

### Removal:

1. Park machine safely. See "Park Machine Safely" in the Safety section.
2. Remove air cleaner cover and air filter assembly.



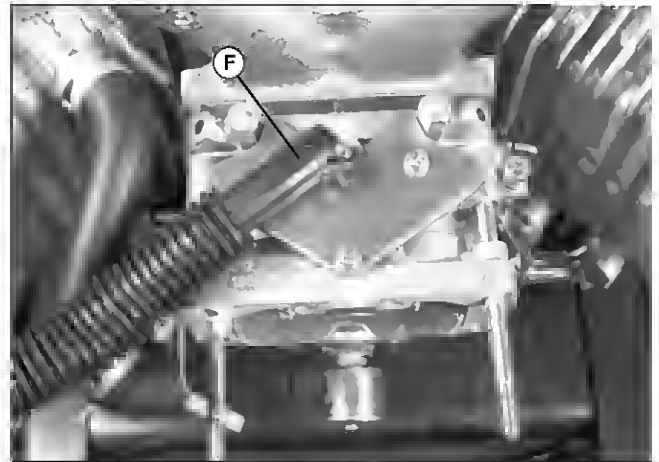
3. Rotate clip (A) and disconnect choke rod from choke shaft.
4. Carefully disconnect throttle rod spring (B) from clip (C). Rotate clip and disconnect throttle rod from throttle shaft.



5. Loosen the clamp and remove the breather hose (D) from the air cleaner base.
6. Disconnect the wire connector (E) from the fuel shutoff solenoid.
7. Remove the two capscrews and two nuts holding the carburetor and air cleaner base to the intake manifold.
8. Carefully pull air cleaner base away from carburetor.



**Caution: Avoid Injury! Gasoline vapor is explosive. Do not expose to spark or flame. Serious personal injury can result.**



9. Disconnect and plug the fuel inlet line (F).
10. Remove the carburetor.

### Installation:

1. Installation is the reverse of removal.
2. Clean the carburetor and intake manifold mating surfaces.
3. Use new intake manifold gaskets during installation.
4. Replace the insulator between the intake manifold and carburetor if worn or damaged.
5. Slide the carburetor into position. Install the mounting bolts and nuts. Tighten to specification.

### Specifications:

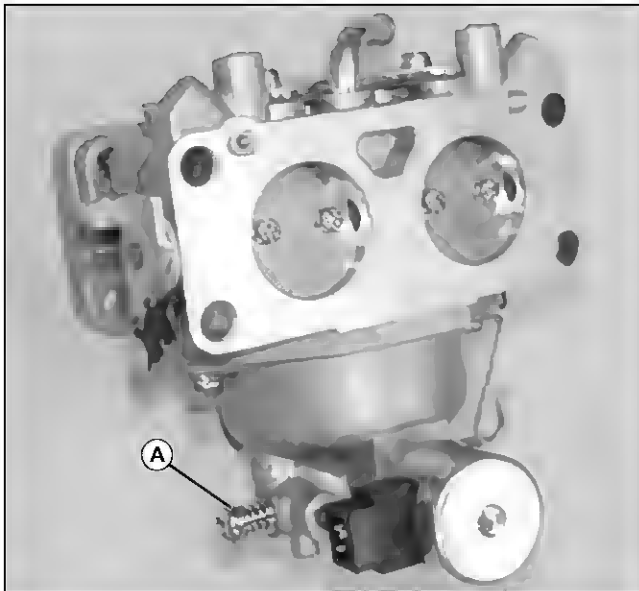
**Mounting Bolts and Nuts Torque . . . 5.9 N•m (52 lb-in.)**

# ENGINE - KAWASAKI (FH661V, FH721V) REPAIR

## Carburetor Repair

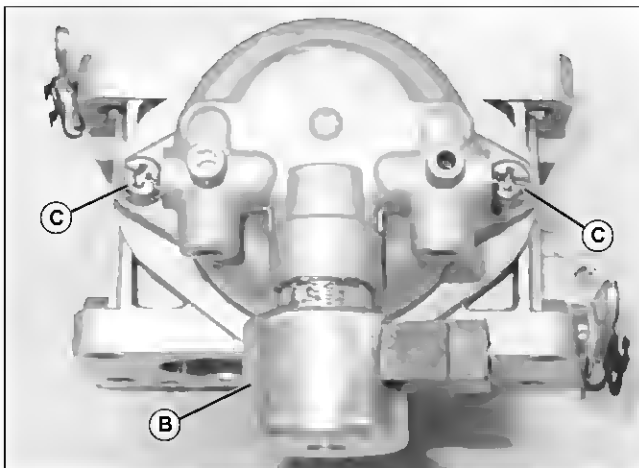
### Disassembly:

1. Remove carburetor from engine. See "Carburetor Removal and Installation" on page 119.



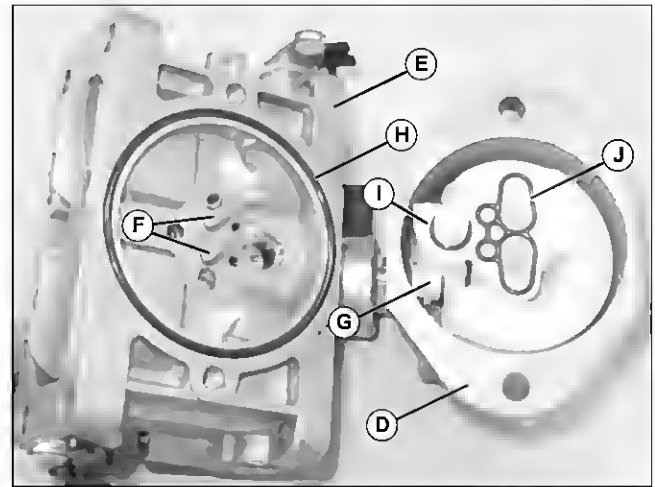
MX33479

2. Remove the float chamber drain screw and spring (A).



MX33480

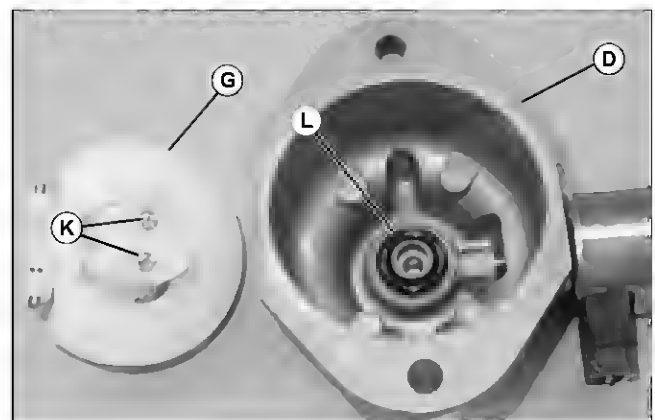
3. Remove the fuel shutoff solenoid (B), and two screws (C) holding the float chamber to the carburetor body.



MX33481

4. Carefully pull the float chamber (D) straight away from the carburetor body (E). Do not damage either the pickup tubes (F) or the float assembly (G).

5. Carefully remove O-rings (H and I) and the rubber gasket (J) and inspect for damage.

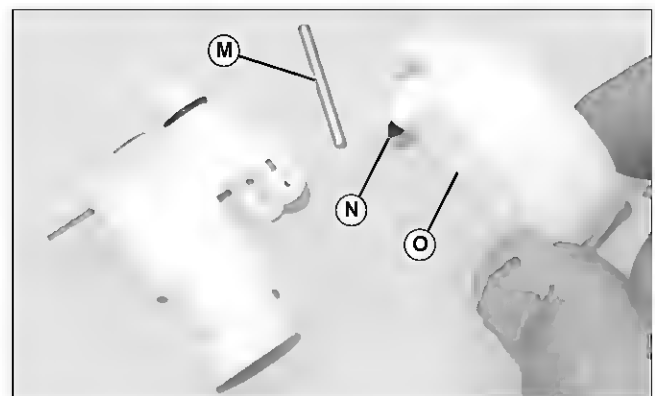


MX33482

6. Lift the float assembly (G) out of the float chamber (D).

7. Inspect the main jets (K) for dirt, wear, or damage.

8. Inspect the oil ring (L) for damage. Clean the float chamber.

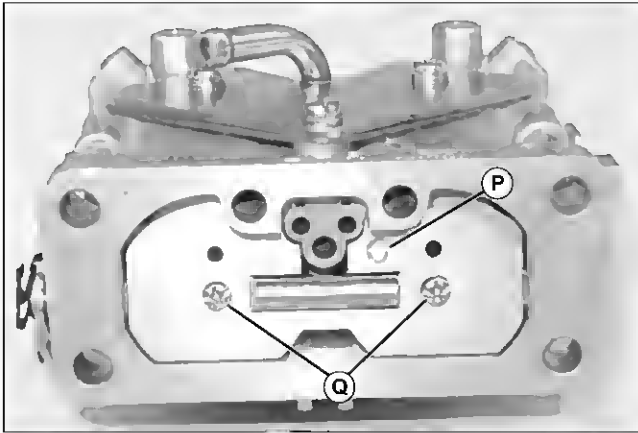


MX33537



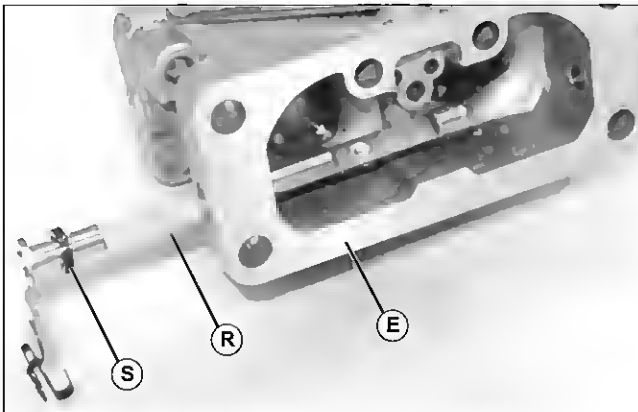
## ENGINE - KAWASAKI (FH661V, FH721V) REPAIR

9. Remove the float pivot pin (M) out from the side opposite the throttle lever of the float hinge.
10. Remove the float valve (N) from the float (O).
11. Inspect the float valve seat for wear or damage. Replace as needed.



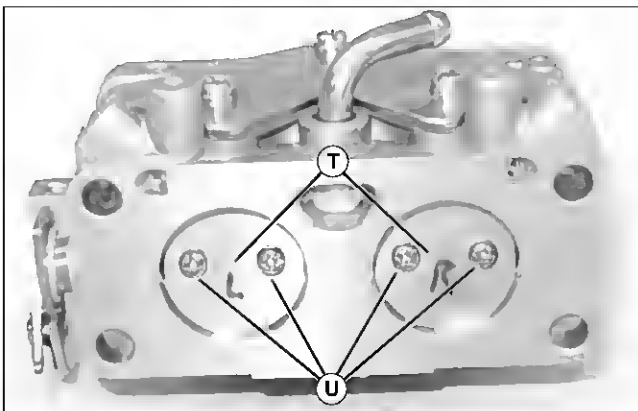
MX33539

12. Mark the choke plate (P) so it can be installed in the original position. Remove two screws (Q) securing the choke plate to the choke shaft.



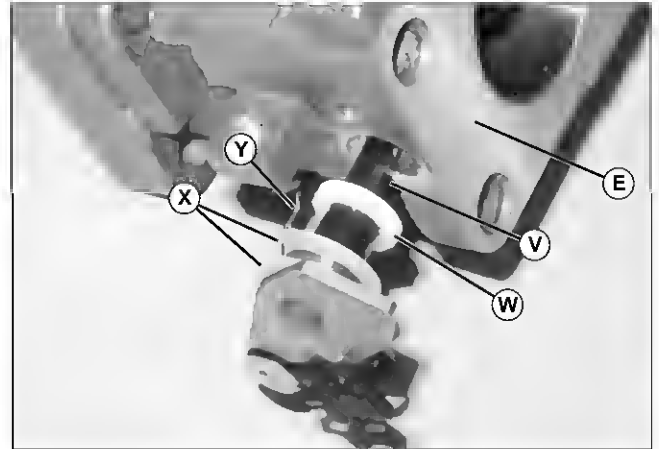
MX33540

13. Slide the choke shaft (R) and shaft seal (S) out of the carburetor body (E).



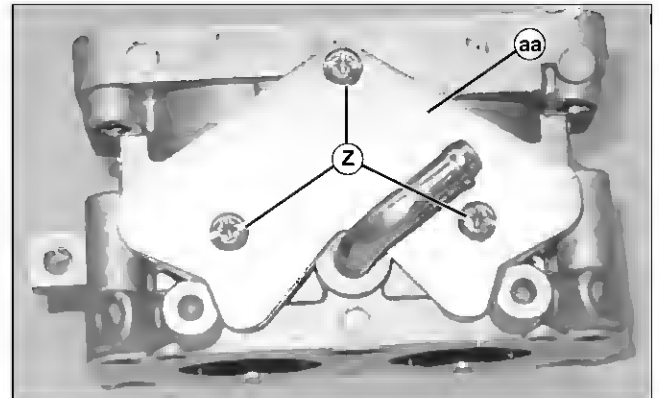
MX33541

14. Mark the throttle valve plates (T) so they can be installed in the original position. Remove four screws (U) securing the plates to the throttle shaft.



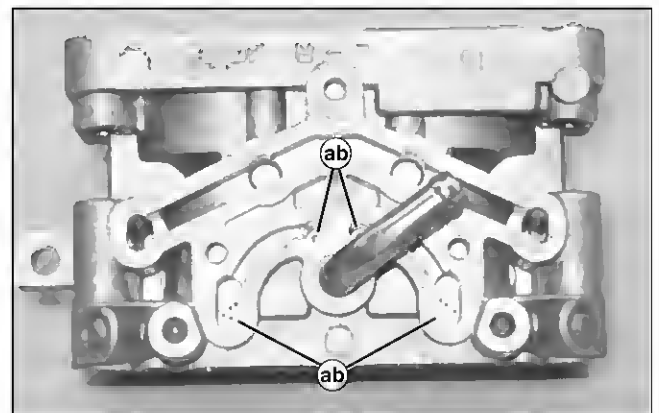
MX33542

15. Slide the throttle shaft (V), shaft seal (W), return spring (X), and spring collar (Y) out of the carburetor body (E).



MX33543

16. Remove three screws (Z), cover plate (AA) and gasket.



MX33544

17. Inspect and clean the passages and holes (AB).

# ENGINE - KAWASAKI (FH661V, FH721V) REPAIR

## Clean/Inspect/Rebuild:

**Important: Avoid Damage! Do not clean holes or passages with small drill bits or wire.**

**Note: When cleaning all rubber and plastic parts, use a cleaning solvent with a high flash point that will not damage these parts when cleaning.**

1. Inspect all moving parts for wear, nicks and burrs, inspect float for leaks or damage. Inspect all mating surfaces for nicks, burrs, foreign material and cracks. Replace all parts that are worn or damaged.
2. Remove rubber and plastic parts from carburetor. Soak all carburetor metal parts in carburetor cleaning solvent for 1/2 hour maximum.
3. Spray all passages with a carburetor cleaning spray to verify that all internal passages are open.

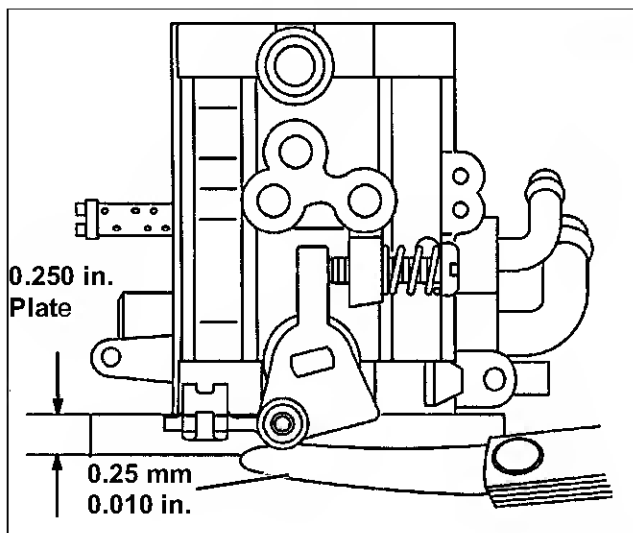


**Caution: Avoid Injury! Reduce compressed air to less than 210 kPa (30 psi) when using for cleaning purposes. Clear area of bystanders, guard against flying chips, and wear personal protection equipment including eye protection.**

4. Rinse carburetor with warm water and dry with compressed air. Do not use rags or paper to dry parts; lint may plug holes or passages.

**Important: Avoid Damage! Rinse carburetor body in warm water to neutralize corrosive action of cleaner on aluminum.**

5. Inspect all parts for wear or damage, replace as necessary.



M89909

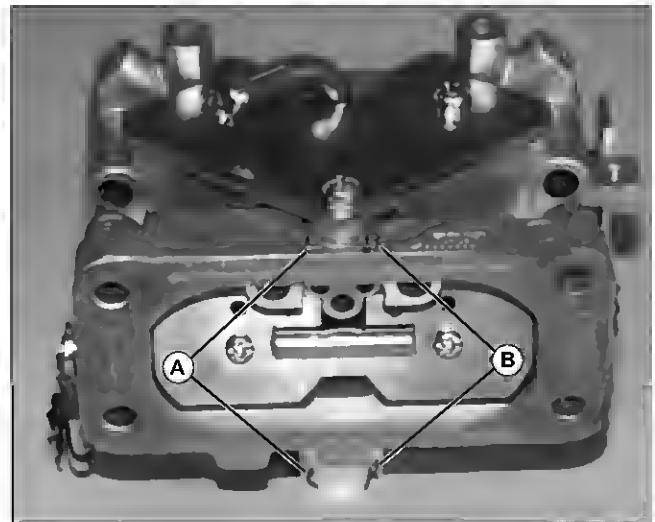
6. Check throttle and choke shafts and bushings for wear.

7. Check wear by placing carburetor on 6 mm (1/4 in.) raised flat surface. Measure the up and down movement of the shaft with a feeler gauge or dial indicator while moving the shaft up and down. Wear between shafts and carburetor bushings should not exceed 0.25 mm (0.010 in.).

## Remove and Install Jets:

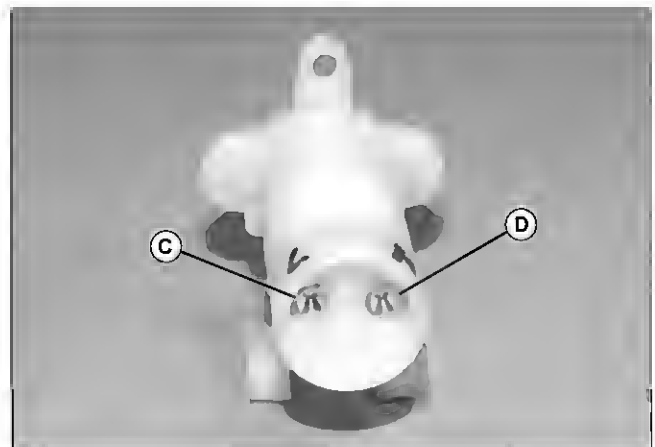
**Important: Avoid Damage! Do not clean holes or passages with small drill bits or wire.**

**Note: When cleaning all rubber and plastic parts, use a cleaning solvent with a high flash point that will not damage these parts when cleaning.**



MX33798

1. Position the jet body onto the carburetor body and mark the jet body with a "L" (A) and "R" (B) to match the carburetor body.
2. Remove the pickup body.



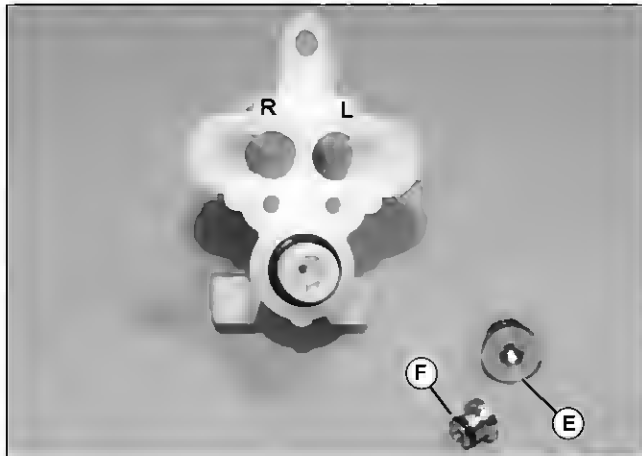
MX33799

3. Carefully press each jet (C and D) into the pickup body to remove.

# ENGINE - KAWASAKI (FH661V, FH721V) REPAIR

**Important: Avoid Damage! Main jets are not the same from left to right side. The right jet is the larger number jet. Jets are changed for different altitudes. Refer to parts catalog for correct jet numbers.**

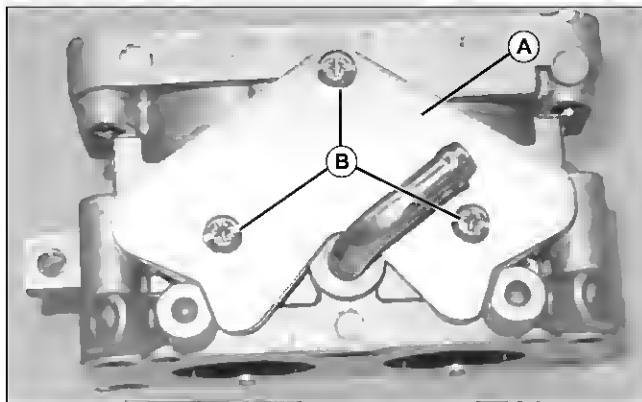
**Note: There are different jets for different altitude ranges. The lower the jet number the less fuel and the leaner the engine will run. Higher altitudes need less fuel and lower jet numbers. The LEFT jet should be two numbers lower than the RIGHT jet. Refer to a current parts catalog for correct jets for your application.**



MX33800

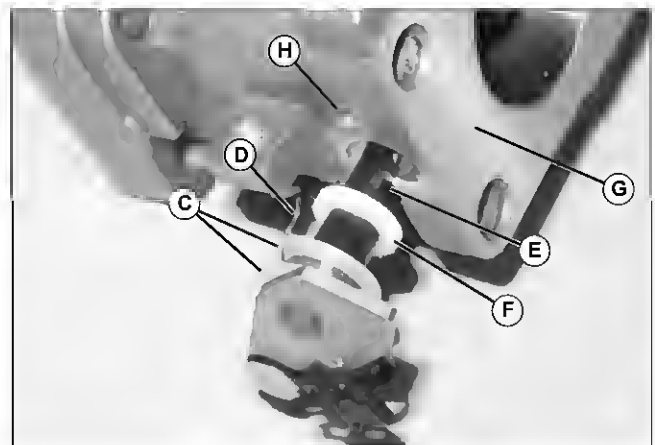
4. Match jet number (E) to the correct side (Left or Right) and install jet, O-ring end first (F), into the pickup body.
5. Align the jet to the pickup bore and carefully press the jet into the pickup body until fully seated.

## Assembly:



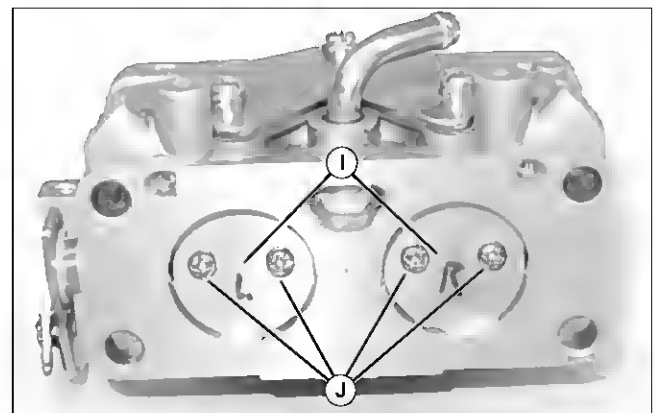
MX33543

1. Position the gasket and cover (A) over the passages and secure with three screws (B).



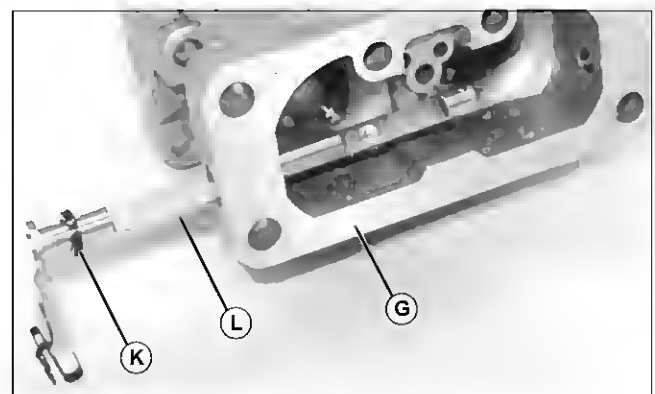
MX33542

2. Slide the spring collar (C) with the return spring (D) positioned between the halves onto the throttle shaft (E).
3. Slide the shaft seal (F) onto the shaft with the lip of the shaft seal facing the inside of the carburetor.
4. Slide the throttle shaft assembly into the carburetor body (G) and engage the return spring into the retaining hole (H).



MX33541

5. Install the throttle valve plates in their original locations. Insert the throttle valve plates (I) into the carburetor bore over the flats of the throttle shaft. Install four screws (J). Tighten to 1 N•m (9 lb-in.).

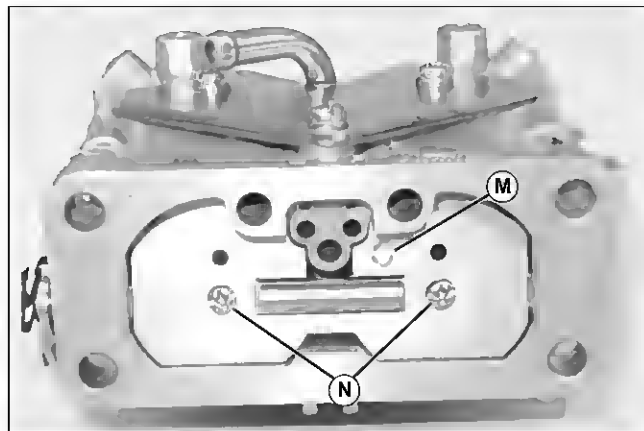


MX33540

6. Slide the choke shaft seal (K) onto the choke shaft (L).

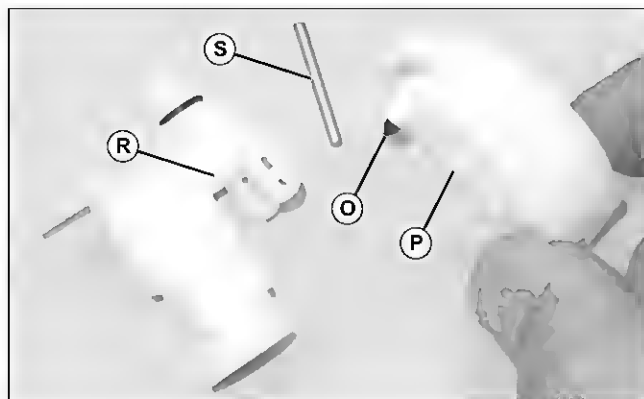
## ENGINE - KAWASAKI (FH661V, FH721V) REPAIR

The lip of the shaft seal should face the inside of the carburetor. Slide the choke shaft assembly into the carburetor body (G).



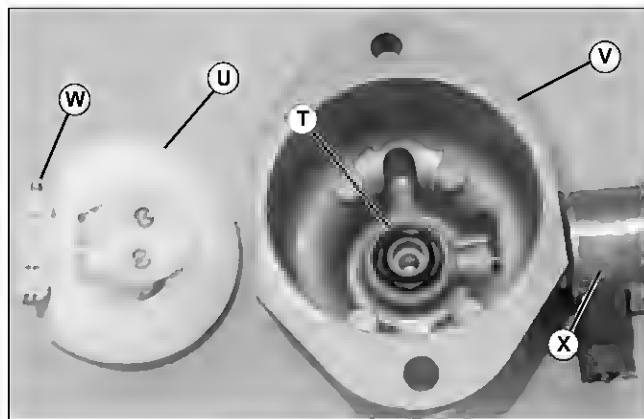
MX33539

7. Install the choke plate in its original location. Place the choke plate (M) into the carburetor throat over the flat surface of the choke shaft. Install two screws (N). Tighten to **1 N•m (9 lb-in.)**.



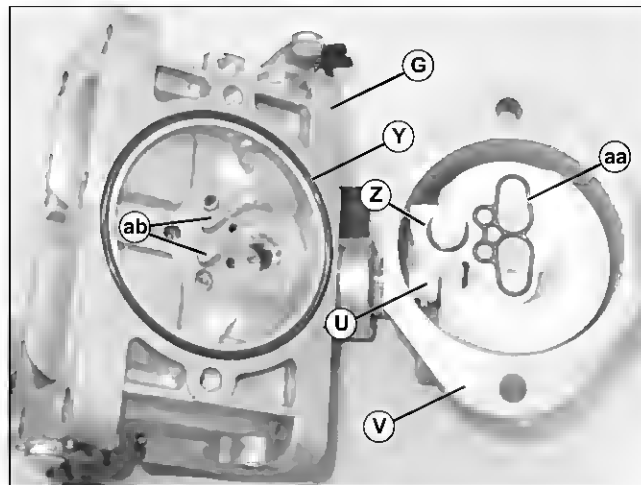
MX33537

8. Hook the float valve (O) into the float (P). Place the float and float valve onto the pickup body (Q) so the valve is seated into the inlet jet (R) and the float pin (S) is aligned. Install the float pin.



MX33482

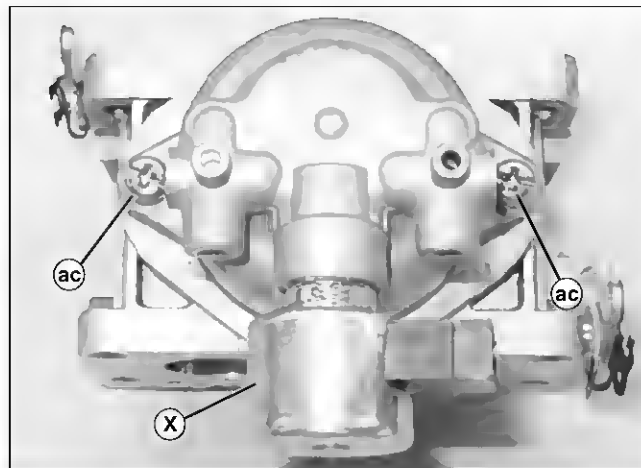
9. With the O-ring (T) in position, install the float assembly (U) into the float chamber (V) with the float hinge (W) toward the fuel shutoff solenoid port (X).



MX33481

10. Apply a light coat of grease to the O-rings (Y and Z) and the rubber gasket (AA) and install in the proper grooves.

11. Carefully set the float chamber (V) straight down onto the carburetor body (G) to prevent damage to the pickup tubes (AB) or the float assembly (U).



MX33480

12. Install two screws (AC) holding the float chamber to the carburetor body and tighten to **4 N•m (34 lb-in.)**.

13. Install the fuel shutoff solenoid (X).

14. Install the float chamber drain screw and spring and tighten to **4 N•m (34 lb-in.)**.

15. Install carburetor to engine. See "Carburetor Removal and Installation" on page 119.

# ENGINE - KAWASAKI (FH661V, FH721V) REPAIR

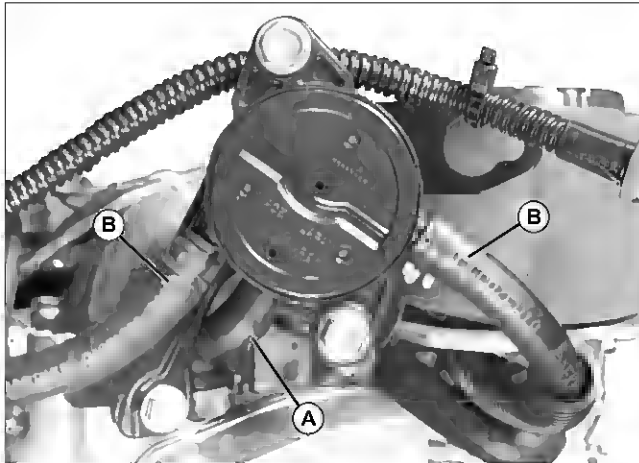
## Fuel Pump Replacement

### Removal:

1. Park machine safely. See "Park Machine Safely" in the Safety section.



**Caution: Avoid Injury! Gasoline is extremely flammable. Do not smoke. Always work in a ventilated area away from open flame or spark producing equipment, this includes equipment that utilizes pilot lights.**



MX36435

2. Disconnect vacuum line (A) and fuel lines (B).
3. Remove two mounting screws.

### Installation:

Installation is done in the reverse order of removal.

- Tighten mounting screws to specification.

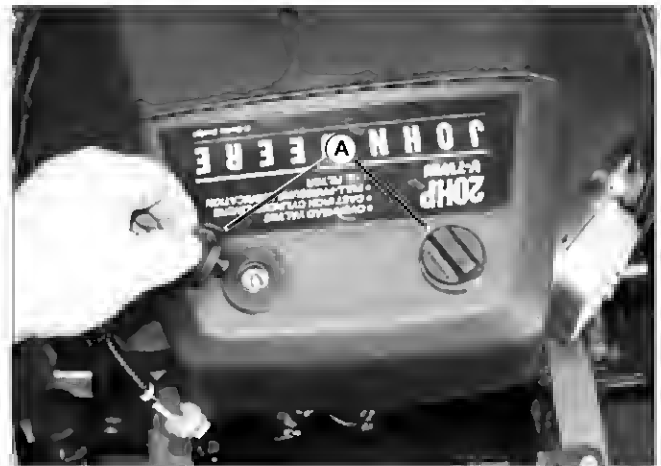
### Specification:

**Torque** ..... 5.9 N•m (52 lb-in.)

## Blower Housing Removal and Installation

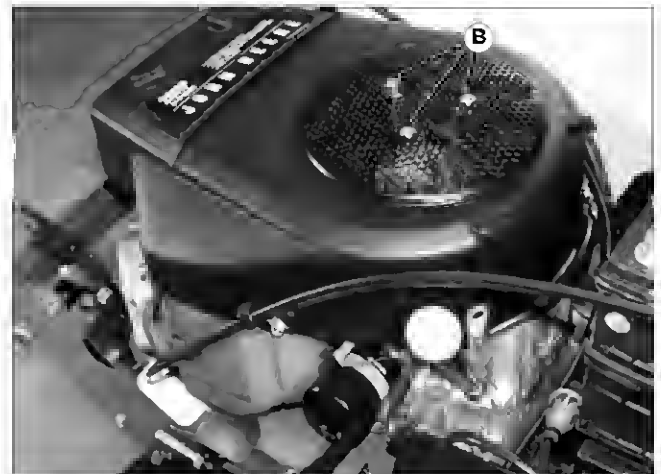
### Removal:

1. Park machine safely. See "Park Machine Safely" in the Safety section.



M99817

2. Remove the two retainer nuts (A) and air cleaner cover from the engine.



M99837

3. Remove three screws (B) and blower screen.



M99838

# ENGINE - KAWASAKI (FH661V, FH721V) REPAIR

4. Loosen the two cap screws (C) on each side of blower housing by four to five turns. These cap screws do not need to be removed. If these cap screws are removed, be careful not to lose the bushings on each cap screw.

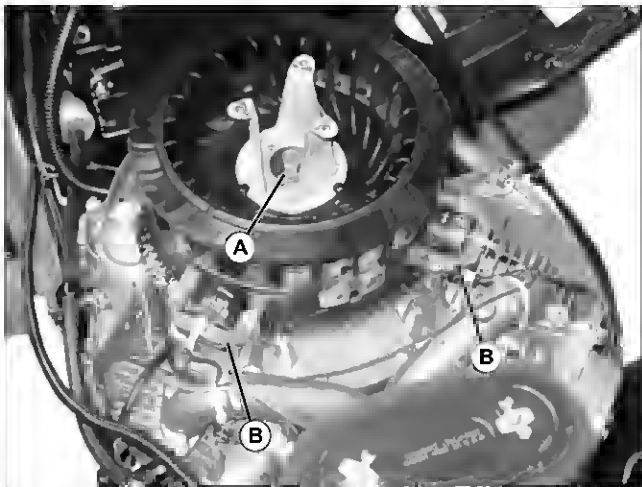
5. Lift the upper blower housing off the engine.

Installation is done in the reverse order of removal.

## Flywheel Removal and Installation

### Removal:

1. Remove blower housing. See "Blower Housing Removal and Installation" on page 125.



MX36322

2. Hold flywheel with strap and remove bolt (A) securing flywheel and debris screen mount.

3. Remove both armature coils (B).



MX36436

4. Remove flywheel using a flywheel puller.

5. Inspect key and keyway for any damage or shearing.

Installation is the reverse order of removal.

- Tighten bolt to specification.

- Adjust armature air gap. See "Ignition Coil Air Gap Adjustment" on page 116.

### Specifications:

**Flywheel Bolt Torque** . . . . . 56 N•m (41 lb-ft)

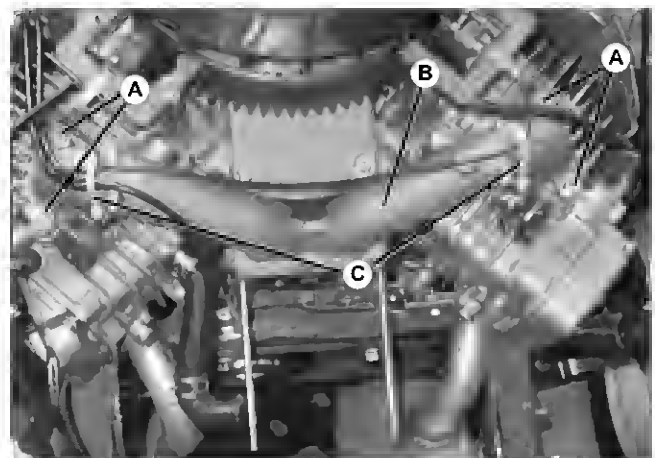
**Ignition Coil Air Gap** . . . . 0.25 - 0.40 mm (0.010 - 0.016 in.)

## Intake Manifold Removal and Installation

### Removal:

1. Remove blower housing. See "Blower Housing Removal and Installation" on page 125.

2. Remove carburetor. See "Carburetor Removal and Installation" on page 119.



MX16333

3. Remove two ties (C) holding ignition coil wires in place on intake manifold.

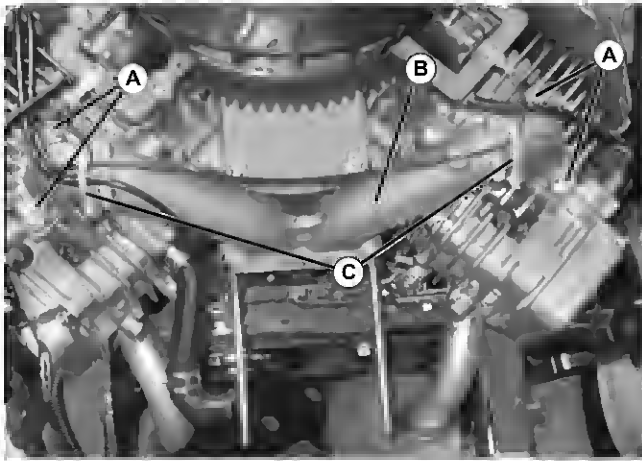
4. Remove four mounting cap screws (A), and intake manifold (B) and two gaskets from engine.

5. Inspect the intake manifold for signs of cracks or porous spots. Inspect the manifold gasket mounting surfaces for burned areas or nicks and gouges. Replace the intake manifold if it is cracked, or the gasket mounting surfaces are damaged to the point they will not seal properly with new gaskets.

### Installation:

1. Clean all old gasket residue off the mating surfaces of the intake manifold and the cylinder heads. Install new gaskets.

# ENGINE - KAWASAKI (FH661V, FH721V) REPAIR



2. Install intake manifold and secure with four (4) mounting cap screws (A). Tighten cap screws to specification.
3. Install two ties (C) to hold ignition coil wires in place on intake manifold.
4. Install carburetor. See "Carburetor Removal and Installation" on page 119.
5. Install blower housing. See "Blower Housing Removal and Installation" on page 125.

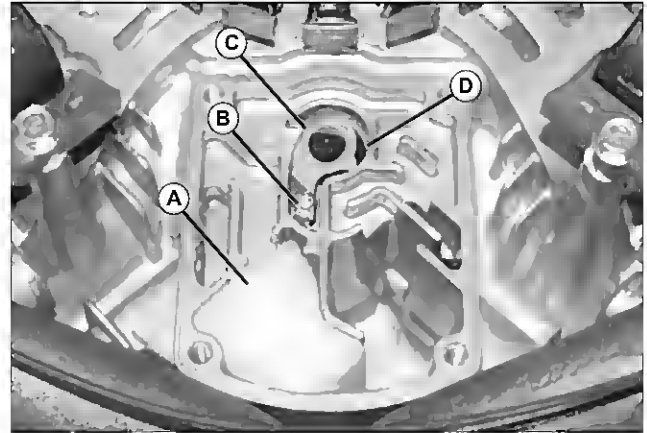
## Specification:

**Mounting Cap Screw Torque . . . . . 5.9 N•m (52 lb-in.)**

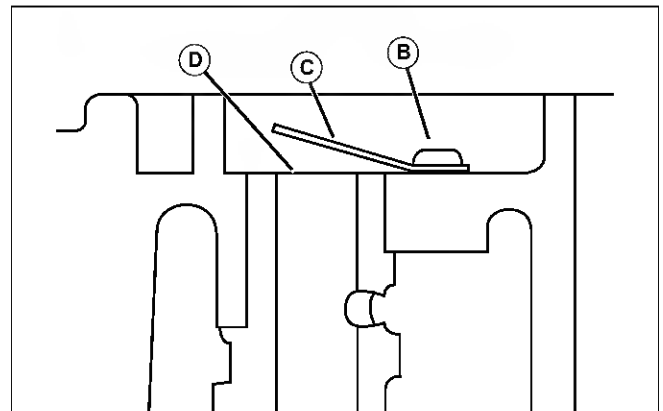
## Breather Removal and Installation

### Procedure:

1. Remove screen and blower housing.
2. Remove flywheel. See "Flywheel Removal and Installation" on page 126.
3. Remove four screws securing the breather chamber cover to the crankcase.



4. Remove and replace breather element (A), or clean with solvent and allow to dry.



5. Remove mounting screw (B), reed plate (C) and breather valve (D).
6. Inspect breather valve (F) for breakage, hairline cracks, or distortion. Inspect the reed plate (C) for damage or rough contact surface. Inspect the valve seating surface it should be free of nicks or burrs. Replace any parts necessary.
7. Check drain hole on breather chamber make sure no foreign material has accumulated before installing breather valve.
8. Align center of the valve seat with center of the breather valve and the plate, then tighten the mounting screw.
9. Install a new gasket.

# ENGINE - KAWASAKI (FH661V, FH721V) REPAIR

10. Install the breather chamber cover and tighten four capscrews to **6.9 N•m (61 lb-in.)**.

11. Install flywheel. See "Flywheel Removal and Installation" on page 126.

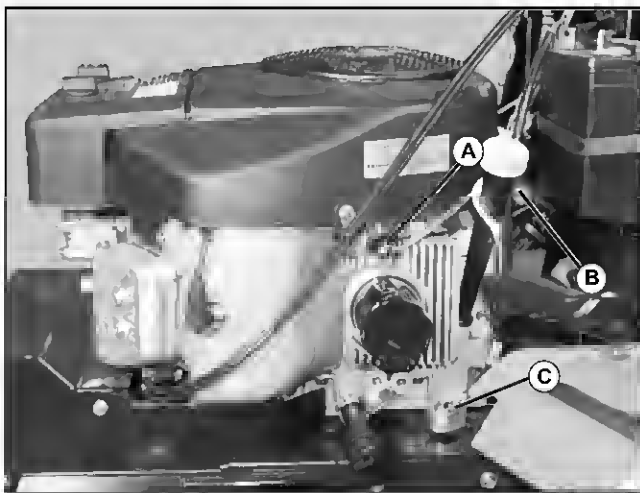
## Engine Removal and Installation

### Removal:



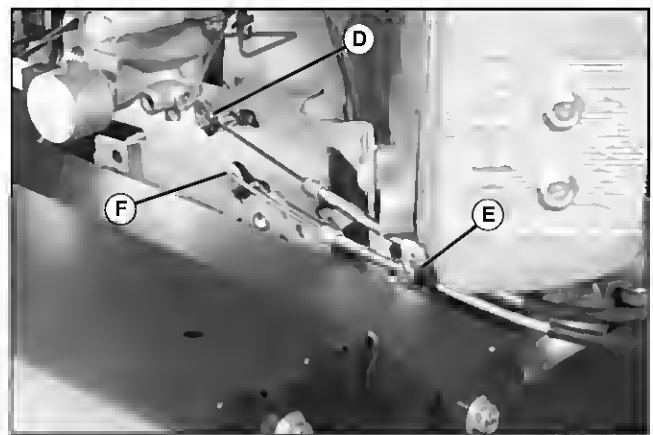
**Caution: Avoid Injury! Engine components may be HOT. Allow engine to cool before removing engine.**

1. Park machine safely. See "Park Machine Safely" in the Safety section.
2. Remove mower deck.
3. Disconnect negative (-) cable from battery.
4. To aid engine removal and installation remove the left side hood bracket.



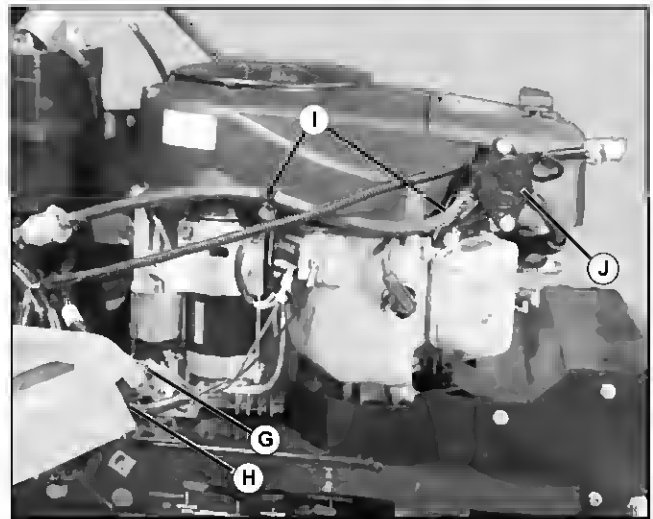
**Picture Note: Left Side**

5. Disconnect the engine wire harness (B) and if equipped, oil pressure switch wire (A). Ground wire (C) will be removed when engine mounting bolts are removed.



MX37058

6. Remove screw with cable retainer (E).
7. Unhook throttle cable (F) and choke cable (D).



MX37057

**Picture Note: Right Side**

8. Disconnect battery positive (+) cable (G) to starting motor solenoid.
9. Disconnect engine wire harness connector (H).

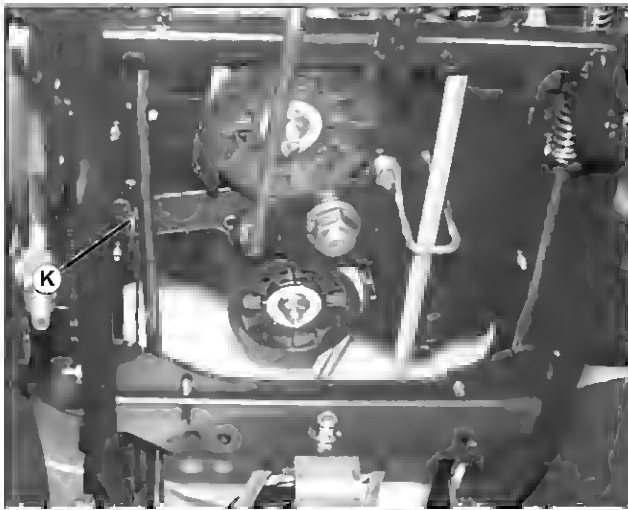


**Caution: Avoid Injury! Gasoline is extremely flammable. DO NOT SMOKE. Always work in a well ventilated area away from open flame or spark producing equipment; this includes equipment that utilizes pilot lights.**

10. Disconnect and plug fuel hose (I) from fuel pump (J).
11. Remove muffler. See "Muffler Removal and Installation" on page 117
12. Remove electric PTO clutch. See "PTO Clutch Removal and Installation" on page 394 in Power Train Section.

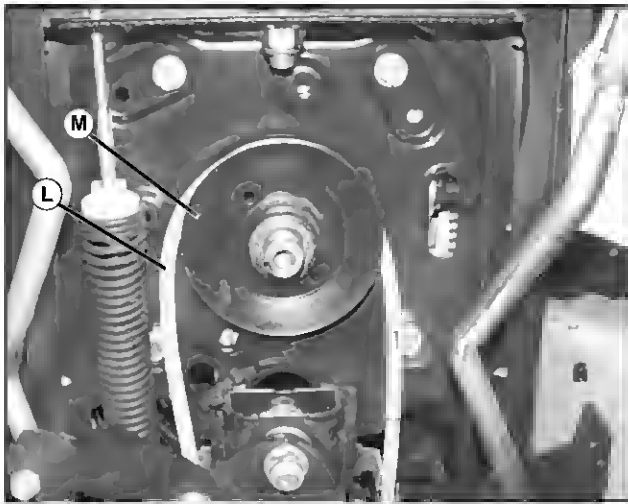


## ENGINE - KAWASAKI (FH661V, FH721V) REPAIR



MX37048

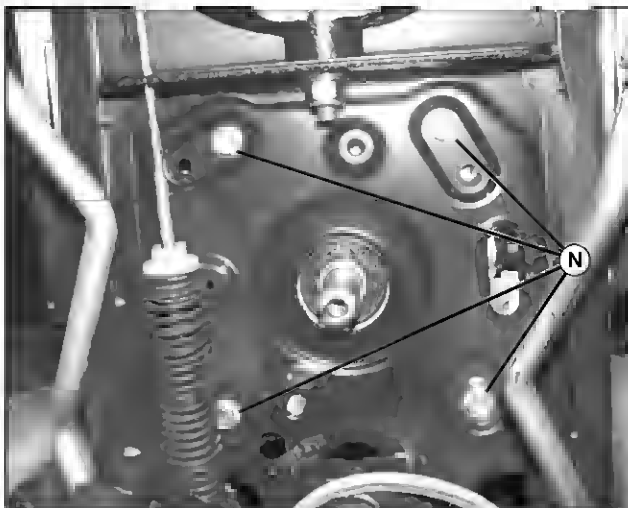
13. Disconnect traction belt tension spring (K).



MX37050

14. Remove drive belt (L) from drive sheave (M).

15. Remove drive sheave from end of crankshaft.



MX37049

16. Remove four mounting cap screws (N).

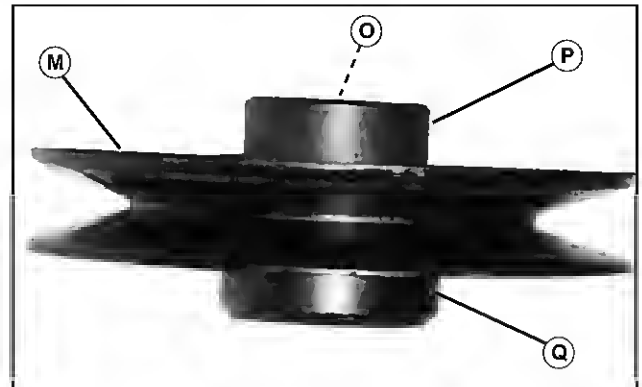
17. Remove engine.

### Installation:

Installation is done in the reverse order of removal.

1. Install four engine mounting cap screws (N). Be sure to connect the ground wire to the left rear mounting cap screw. Tighten cap screws and lock nuts to **26 N•m (230 lb-in.)**.

2. Apply MPG-2 Multipurpose Polymer Grease to engine crankshaft.



MX37051

3. Install traction drive sheave (M) with key (O). Be sure to install small hub (P) against engine and large hub (Q) to clutch.

4. Install belt (L).

5. Install traction belt tension spring (K).

6. Install electric PTO clutch. See "PTO Clutch Removal and Installation" on page 394 in Power Train Section

7. Connect the fuel line to the fuel pump.

8. Connect the battery cable to the starting motor.

9. Connect the engine wire harness to main wiring harness.

10. Connect the throttle cable and choke cable.

11. Adjust throttle cable and choke plate. See "Throttle Cable Check and Adjustment" on page 108.

12. Install muffler.

13. Check oil level.

# ENGINE - KAWASAKI (FH661V, FH721V) REPAIR

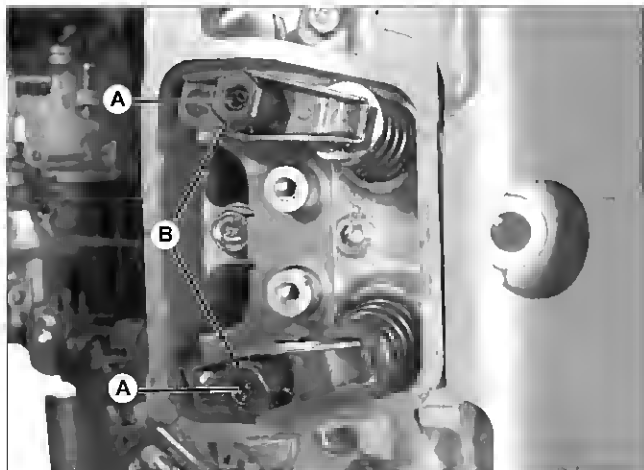
## Rocker Arm Removal and Installation

### Removal:

1. Remove spark plug and rocker arm cover.

**Note:** When piston is at top dead center (TDC) both rocker arms should not have spring tension on them.

2. Turn crankshaft until piston is at TDC of compression stroke for the cylinder being worked on.



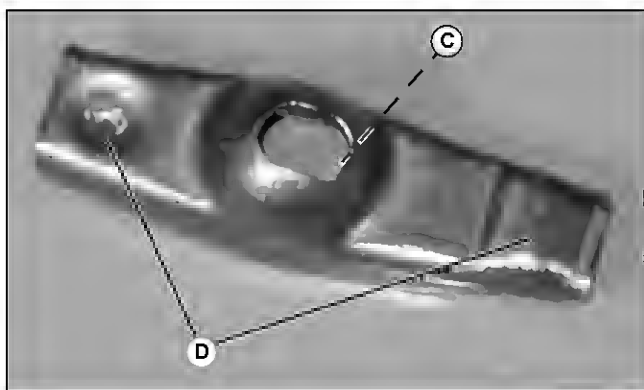
MX36440

3. Hold lock screws (A). Remove valve clearance adjustment nuts (B) and rocker arms.

**Important: Avoid Damage! Mark push rods for reassembly in original locations**

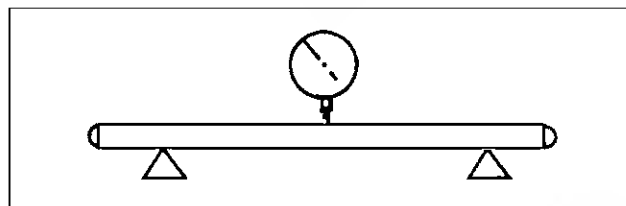
4. Inspect all parts for wear or damage. (See Inspection procedure.)

### Inspection:



MX36924

- Clean and inspect the rocker arm where it contacts the push rod and valve stem (D). Check the inside of the rocker arm where it pivots on the special nut (C). If the contact points are worn or damaged, replace the rocker arm.



M50044

- Inspect push rod for bend using V-blocks and a dial indicator. Turn rod slowly and read variation on indicator. Replace if variation is greater than 0.5 mm (0.020 in.).

### Installation:

Installation is done in the reverse order of removal.

**Important: Avoid Damage! Align rocker arms over push rods during assembly**

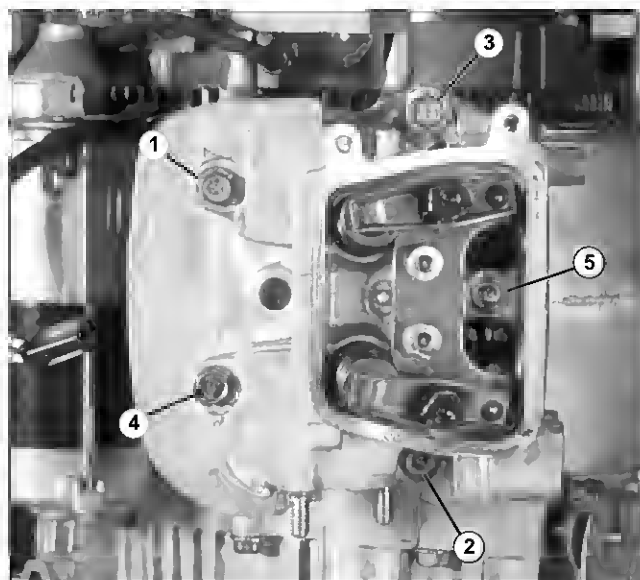
- Check and adjust valve clearance. See "Valve Clearance Check and Adjustment" on page 111.
- Install rocker covers. Tighten rocker cover cap screws to 6.9 N•m (61 lb-in.).

## Cylinder Head Removal and Installation

### Removal:

1. Remove the following using procedures in this section:

- Upper blower housing
- Air cleaner and carburetor assemblies
- Muffler
- Intake manifold
- Spark plug
- Cylinder shields



MX36926

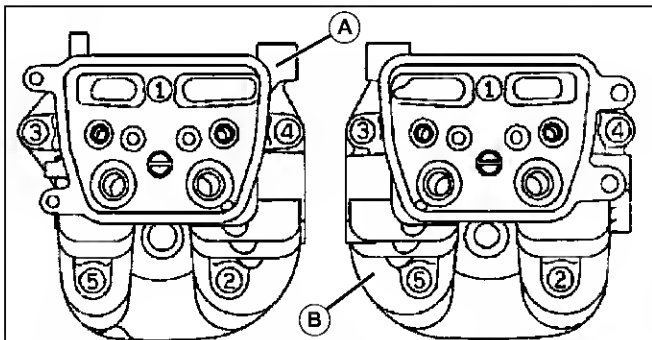
# ENGINE - KAWASAKI (FH661V, FH721V) REPAIR

2. Remove rocker cover and gasket.
3. Turn crankshaft until piston is at TDC of compression stroke for the cylinder being worked on.
4. Loosen the cylinder head bolts 1/4 turn at a time, in sequence (above) to prevent warping the cylinder head during removal.
5. Remove cylinder head assembly.
6. Mark push rods for installation in their original position during assembly.
7. Remove rocker arms. See "Rocker Arm Removal and Installation" on page 130.

## Installation:

**Important: Avoid Damage! Gasket surfaces are coated with sealant. Do not damage surfaces or gasket during installation.**

1. Set cylinder to TDC of compression stroke for the cylinder being worked on.
2. Set the cylinder head with gasket onto crankcase.
3. Slide the push rods into the crankcase by sliding the end of the rods down along the inside wall of the crankcase.
4. Position the push rod end on the tappet.
5. Align the upper push rod end under the rocker arms.



M95386

6. Torque should be applied in the sequence shown, in 7 N•m (62 lb-in.) increments for the number one (A) and number two (B) cylinders.

## Torque Specifications:

**First torque** ..... 7 N•m (62 lb-in.)  
**Second torque** ..... 14 N•m (124 lb-in.)  
**Third torque** ..... 21 N•m (186 lb-in.)  
**Final torque** ..... 25 N•m (221 lb-in.)

7. Install the rocker arms. See "Rocker Arm Removal and Installation" on page 130.
8. Check and adjust valve clearance. See "Valve

Clearance Check and Adjustment" on page 111.

9. Install rocker covers. Tighten rocker cover cap screws to 5.9 N•m (52 lb-in.).

## Cylinder Head Inspection

### Procedure:

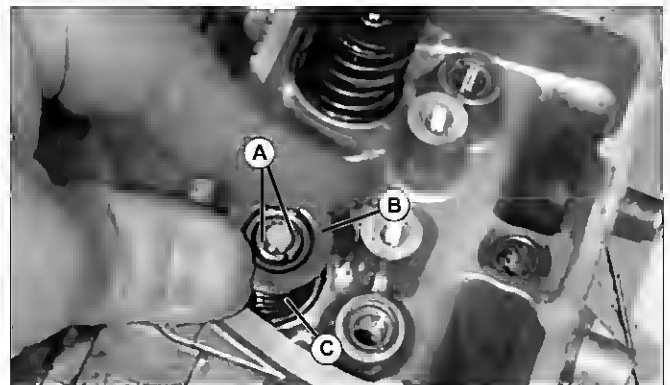
1. Remove cylinder heads. See "Cylinder Head Removal and Installation" on page 130.
2. Remove carbon deposits from combustion chamber and gasket surface using SCOTCH-BRITE® abrasive pads or an equivalent.



**Caution: Avoid Injury! Reduce compressed air to less than 210 kPa (30 psi) when using for cleaning purposes. Clear area of bystanders, guard against flying chips, and wear personal protection equipment including eye protection.**

3. Clean head with a suitable solvent and dry with compressed air.
4. Inspect for cracks or broken cooling fins.
5. Inspect gasket surface for burrs and nicks.
6. Inspect head gasket for burns and traces of gas leakage.
7. Check that oil drainback passages are not plugged.
8. Put cylinder head on a surface plate. Check for distortion at several points around the head using a feeler gauge. Replace head if distortion is more than 0.05 mm (0.002 in.).

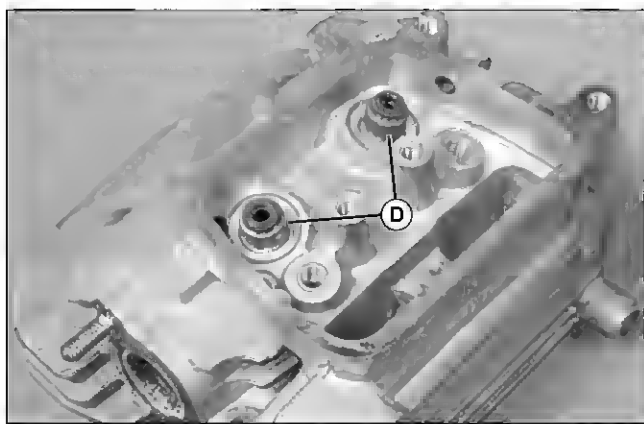
## Disassembly and Assembly:



M95402

1. Compress valve spring and remove collet halves (A).
2. Remove spring retainer (B) and spring (C).

# ENGINE - KAWASAKI (FH661V, FH721V) REPAIR



3. To replace stem seal, carefully pry up from bottom (D) with a screwdriver.

4. Inspect springs, valves, guides, and seals. (See Inspection procedure.)

Assembly is done in the reverse order of disassembly.

## Valve Guides:

**Note:** Intake and exhaust valve guides cannot be replaced, replace head if worn.

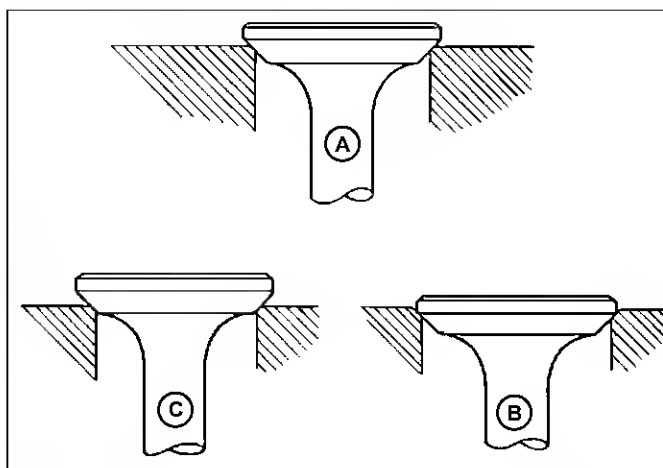


1. Clean inside of valve guides (E) with valve guide cleaner.

2. Measure inside diameter of valve guides in several places down the length of the guide. Replace cylinder head if inside diameter is greater than **6.08 mm (0.239 in.)**.

## Valve Seats:

1. If valve seats are loose, warped or distorted beyond reconditioning, replace cylinder head. Pitted or worn seats can be re-faced using a seat cutter.

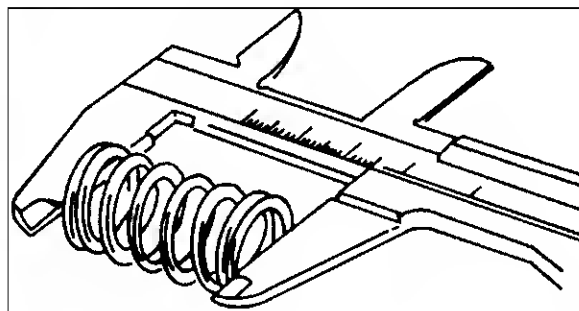


2. Check valve seating pattern for correct width and evenness all around (Note: correct seat position (A), seat too deep (B) and seat too high (C)). If valve seat width is not within **0.8 - 1.4 mm (0.03 - 0.05 in.)** intake or **1.1 - 1.6 mm (0.04 - 0.06 in.)** exhaust, recondition valve seat.

3. Lap valve after reconditioning with lapping compound and recheck valve seating surface for proper width and evenness of seating pattern. See "Lap Valves" on page 134.

## Valve Springs:

1. Inspect spring for pitting, rust, and burrs. Replace if necessary.



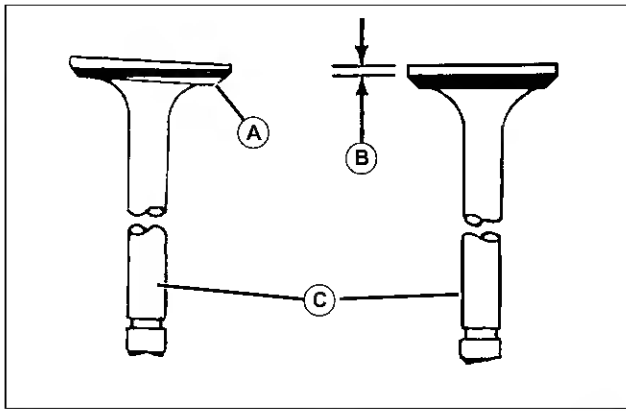
2. Measure spring free length. Replace spring if measurement is less than **31.0 mm (1.22 in.)**.

## Intake and Exhaust Valves:

1. Remove carbon from valve head, face, and stem with a power-operated wire brush. Be sure carbon is removed, not merely burnished.

2. Inspect valve head, face, and stems for defects. Replace if necessary.

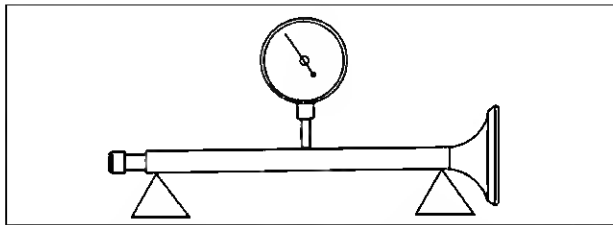
# ENGINE - KAWASAKI (FH661V, FH721V) REPAIR



3. Replace warped valves (A) or valves with less than **0.35 mm (0.014 in.)** margin (B).
4. Measure outside diameter of valve stem (C) in several places. Replace valve if diameter is less than specification.

## Minimum Valve Stem OD Specifications:

**Intake** ..... **5.95 mm (0.234 in.)**  
**Exhaust** ..... **5.93 mm (0.233 in.)**



5. Check valve stem for bend using V-blocks and a dial indicator. Turn valve slowly and read variation on indicator. Replace valve if variation is greater than **0.05 mm (0.002 in.)**.

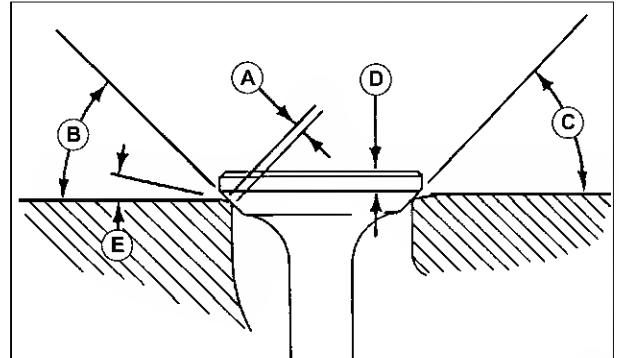
**Important: Avoid Damage! Do not grind the exhaust valve or life will be shortened.**

6. Grind the intake valve to **45°**. Replace valve if margin is less than **0.35 mm (0.014 in.)** after grinding.

## Recondition Valve Seats

### Procedure:

1. Inspect valve seats for damage. If seats are warped or distorted beyond reconditioning, replace cylinder head. Pitted or worn seats can be refaced using a seat cutter.



2. To recondition seat, cut at **45°** angle (B) to clean up seat. Cut narrowing angle (E) at **30°**. Finish cut at **45°** (B) to establish seating surface width (A).
3. Cut valve seating surface (A) as close as possible to specifications.

### Specifications:

**A - Valve Seating Surface (Standard) Intake** . **0.80 - 1.40 mm (0.03 - 0.055 in.)**  
**(Standard) Exhaust** ..... **1.1 - 1.6 mm (0.04 - 0.063 in.)**  
**B - Valve Seat Angle**..... **45°**  
**C - Valve Face Angle** ..... **45°**  
**D - Valve Margin (Minimum)** ..... **0.35 mm (0.014 in.)**  
**E - Valve Narrowing Angle**..... **30°**

4. Lap valves to seats after re-facing. See "Lap Valves" on page 134.
5. Center valve seat on the valve face.
6. Check seat for good contact using Prussian Blue Compound.

# ENGINE - KAWASAKI (FH661V, FH721V) REPAIR

## Lap Valves

### Procedure:

**Note:** If valve seat does not make proper contact, lap the valve into the seat.



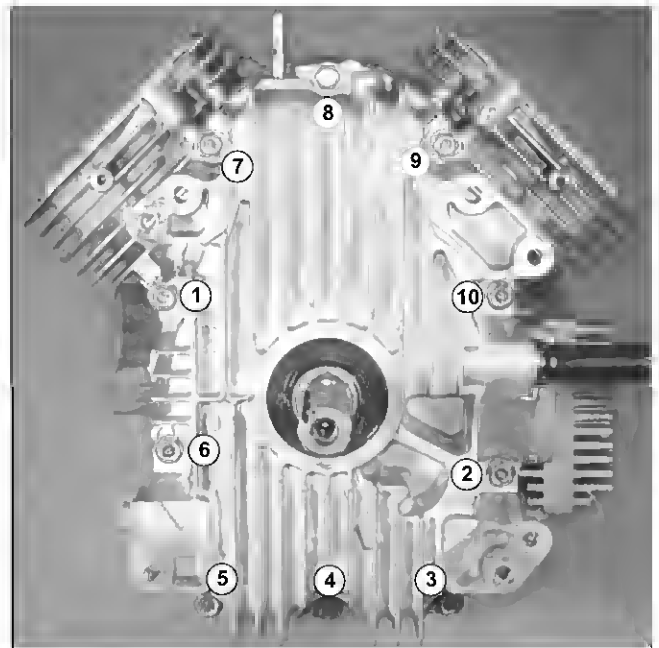
1. Apply a small amount of fine lapping compound to face of valve.
2. Grip top of valve with a vacuum cup tool (A) and rotate valve to lap valve to seat.
3. Lift valve from seat every 8 to 10 strokes. Lap until a uniform ring appears around the surface of the valve face.
4. Wash all parts in solvent to remove lapping compound. Dry all parts.
5. Check position of lap mark on valve face. Lap mark must be on or near center of valve face.

## Crankcase Cover Removal and Installation

### Removal and Installation:

1. Drain crankcase. Capacity (with filter) is approximately 1.7 L (1.8 US qt).
2. Remove crankcase cover and gasket.
3. Clean crankcase and crankcase cover gasket surfaces.

**Note:** Do not force cover. Gears must mesh for proper positioning.



4. Install gasket and cover. Tighten cap screws in a two step process to specification. Use the sequence shown above.

### Torque Specifications:

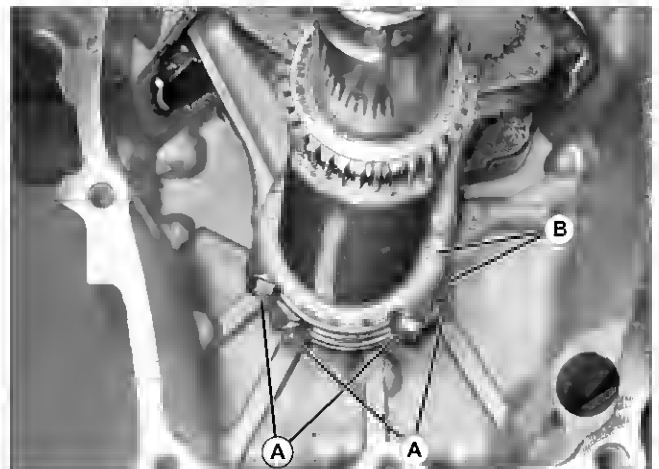
**Initial torque** ..... 10 N•m (88 lb-in.)

**Final torque**..... 25 N•m (221 lb-in.)

## Piston and Connecting Rod

### Removal:

1. Remove cylinder head.
2. Remove the crankcase cover.
3. Remove the camshaft.
4. Turn the crankshaft to expose the connecting rod cap screws.



# ENGINE - KAWASAKI (FH661V, FH721V) REPAIR

5. Remove the cap screws (A). Take off the connecting rod caps (B). Note the position of the connecting rod caps for reinstallation.
6. Check cylinder bore for carbon and varnish ridges. These ridges can cause piston damage if not removed.
7. If necessary, remove ridges from top of cylinder bore with a ridge reamer.
8. Push piston and connecting rod up into the cylinder and pull out of the cylinder bore.

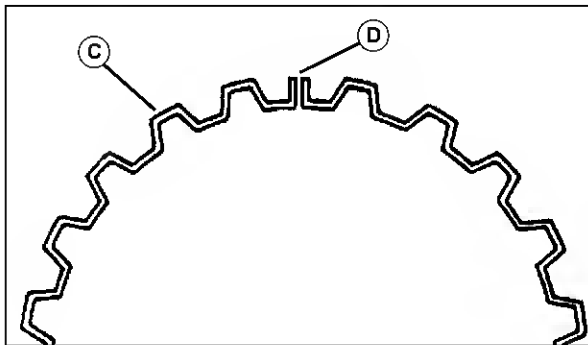
## Disassembly:

- Remove piston rings with a piston ring expander.
- Inspect all parts for wear or damage. Replace as necessary.

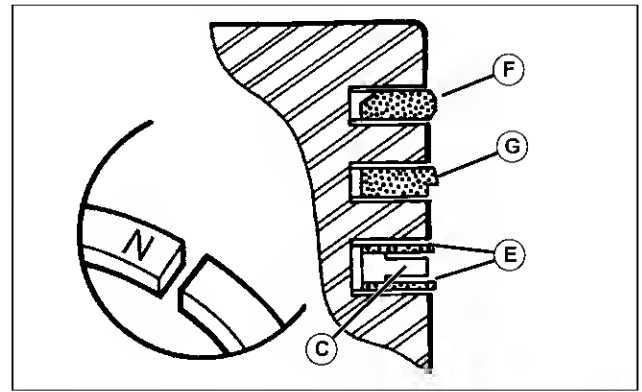
**Note:** Location of the arrow match mark on the piston head in relation to "K" mark on the connecting rod. Keep parts together as a set.

1. Remove one of the piston pin snap rings with a needle nose pliers.
2. Remove the piston pin by pushing it out of the side of the piston that has the ring removed.
3. Using a piston ring pliers, remove the top and second rings.
4. Remove the three piece oil ring.

## Assembly:



1. Install the expander (C) in the piston oil ring groove so that the expander ends (D) touch together. Be sure that they do not overlap.
2. Install the upper and lower steel oil rails. There is no up or down to the rails. They can be installed either way.



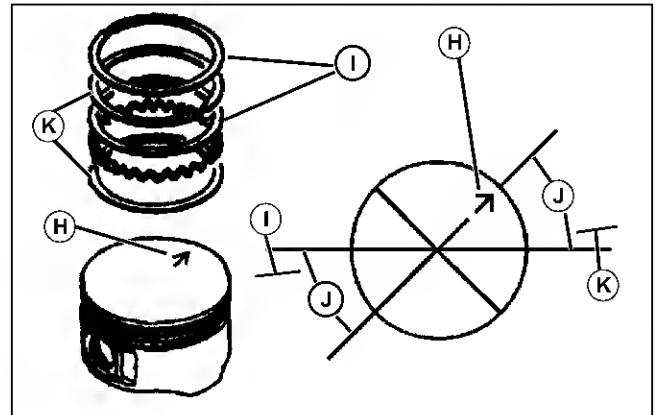
C - Expander

E - Steel Oil Rails

F - First Chrome - Plated Compression Ring

G - Second Compression Ring

3. Install the second ring and chrome-plated top ring with "N" mark facing up. The rings should turn freely in the grooves.



H - Arrow match mark

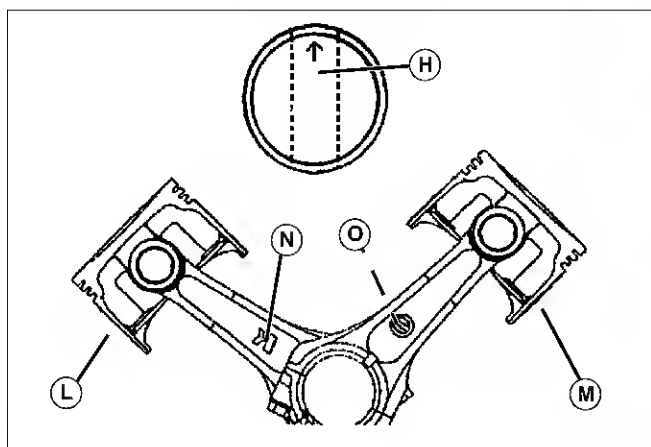
I - Top ring end gap, upper steel rail end gap

J - 30° - 45°

K - Second ring end gap, lower steel rail end gap

4. Align the piston and rings with the piston ring end gap as shown above.
5. Apply a light film of clean engine oil to piston pin and connecting rod bearing during assembly.

# ENGINE - KAWASAKI (FH661V, FH721V) REPAIR



M95392

H - Arrow match mark

L - No. 1 Cylinder Piston

M - No. 2 Cylinder Piston

N - "K" Mark

O - "K" Mark on Opposite Side

6. No. 1 cylinder piston:

Align the arrow match mark on the piston head opposite the raised letter "K" mark on the connecting rod.

7. No. 2 cylinder piston:

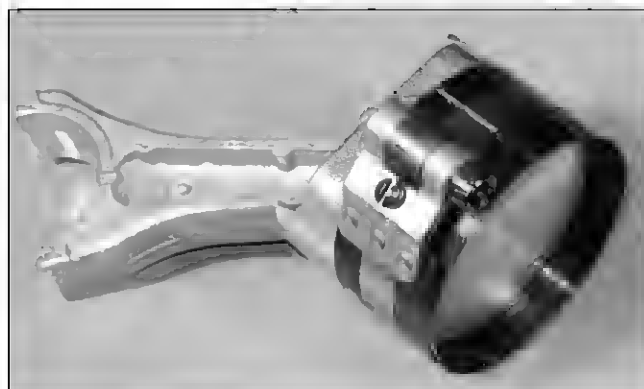
Align the arrow match mark on the piston head with the raised letter "K" mark on the connecting rod.

8. Install piston pin and snap ring. Compress snap ring only enough to install the snap ring.

9. Fit a new piston pin snap ring into the side of the piston so that the ring opening of the snap ring does not coincide with the notch in the edge of the piston pin hole.

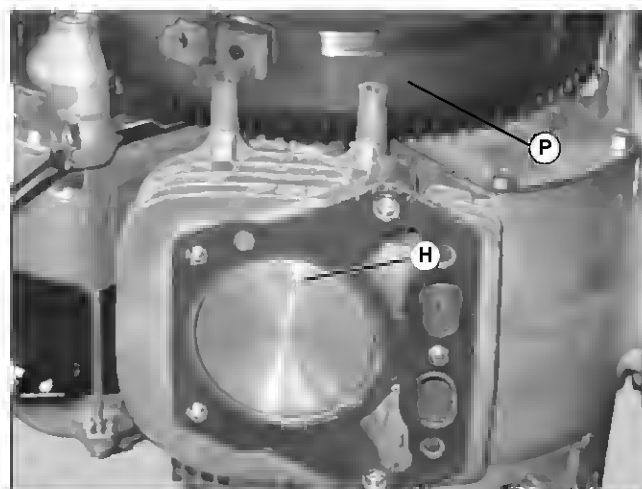
## Installation:

1. Deglaze cylinder bore.



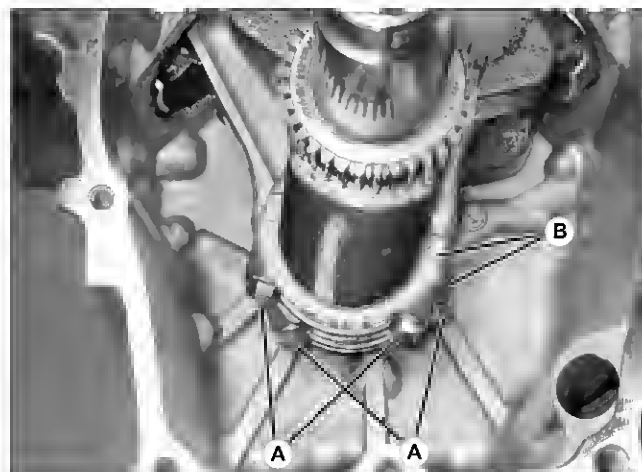
MX36931

2. Apply a light film of oil to piston and rings. Compress rings with a ring compressor.



MX36932

3. Install piston assembly in cylinder bore with engraved match mark/arrow (H) on piston head facing flywheel side (P) of engine.



MX36930

4. Install connecting rod caps (B) and cap screws (A) in their original positions. Tighten cap screws to **9.8 N•m (87 lb-in.)**.

5. Install crankcase cover and cylinder head.

## Piston Inspection:

**Important: Avoid Damage! Do not use a caustic cleaning solution or a wire brush to clean piston.**

1. Remove all deposits from the piston.
2. Clean carbon from piston ring grooves with a ring groove cleaner. If cleaning tool is not available, break an old ring and use it to carefully clean groove.
3. Check that oil return passages in grooves are open.
4. Inspect piston for scoring or fractures. Replace piston if damaged.



# ENGINE - KAWASAKI (FH661V, FH721V) REPAIR



5. Check ring grooves for wear at several points around piston. Replace piston if clearance is greater than specifications.

## Ring Groove Side Clearance Specifications:

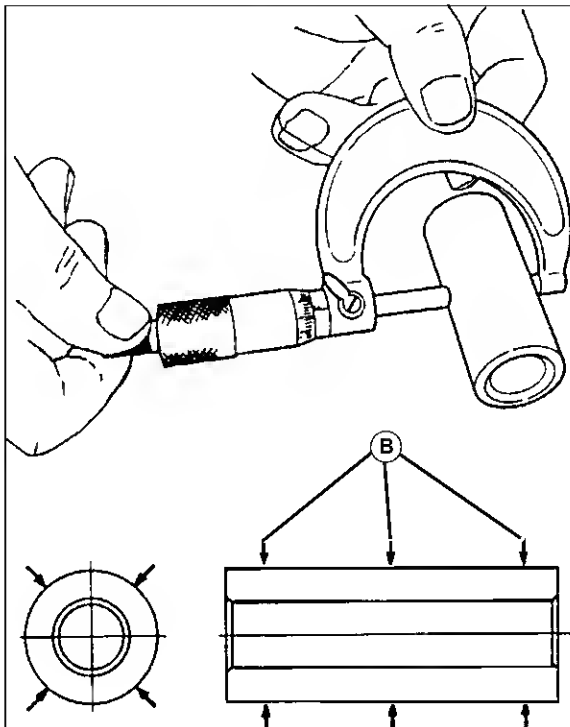
1st Compression Ring (Top) . . . . . 0.18 mm (0.007 in.)

2nd Compression Ring (Middle) . . . 0.16 mm (0.006 in.)

Oil Ring . . . . . Visually Check

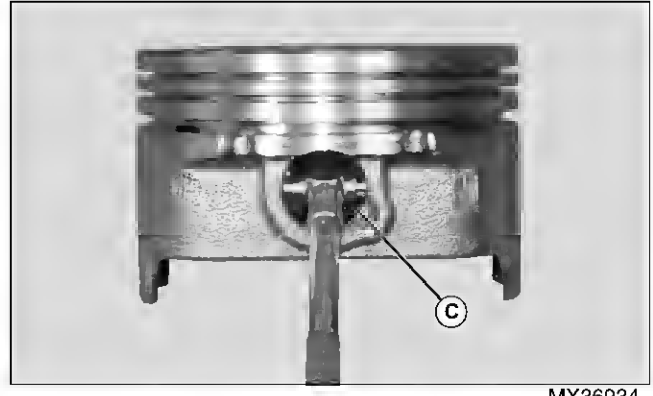
6. The oil ring is a three piece assembled ring. It is difficult to measure the ring groove clearance and thickness, visually inspect only.

7. Remove the spring clip (A) and piston pin to remove piston from connecting rod.



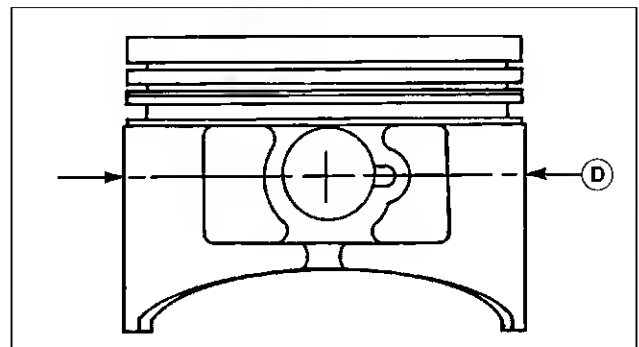
8. Measure piston pin diameter at six places (B). Replace

pin if measurement is less than 15.96 mm (0.628 in.).



9. Measure piston pin bore (C). Replace piston if measurement is greater than 16.08 mm (0.633 in.).

**Note:** If the engine has had a previous major overhaul, **oversize piston and rings may have been installed.** Piston and rings are available in 0.50 mm (0.020 in.) oversize.



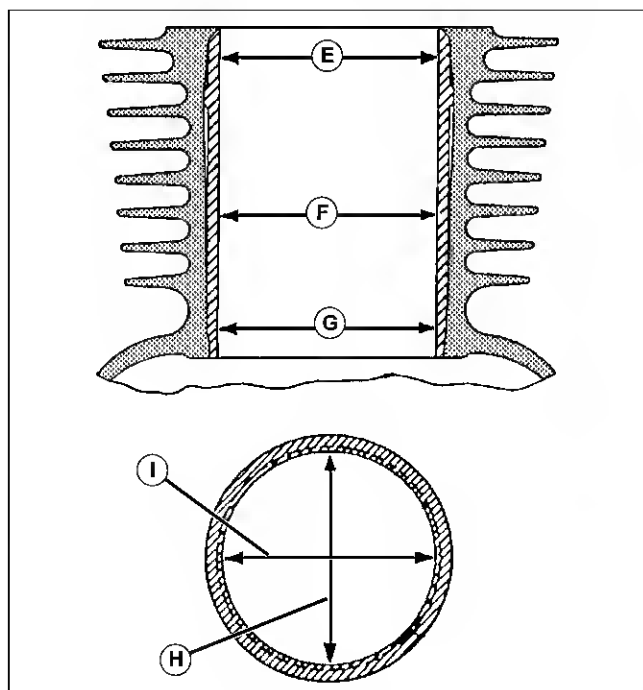
10. Measure piston OD (D) perpendicular to piston pin bore. If piston diameter is less than specifications, install a new piston.

## Piston OD Specifications:

Standard Piston . . . . . 74.99 mm (2.950 in.)

Oversized Piston . . . . . 75.49 mm (2.970 in.)

# ENGINE - KAWASAKI (FH661V, FH721V) REPAIR



M82411A

11. Measure cylinder bore diameter at three positions; top (E), middle (F) and bottom (G). At these three positions, measure, in both directions; along crankshaft centerline (H) and direction of crankshaft rotation (I).

**Note:** If the engine has had a previous major overhaul, **oversize piston and rings may have been installed. Pistons and rings are available in 0.50 mm (0.020 in.) oversize.**

## Cylinder Bore ID:

### Standard Size Bore:

Standard ..... 75.18 - 75.20 mm (2.960 - 2.961 in.)

Wear Limit ..... 75.28 mm (2.964 in.)

### 0.50 mm (0.020 in.) Oversize Bore:

Standard ..... 75.68 - 75.70 mm (2.979 - 2.980 in.)

Wear Limit ..... 75.78 mm (2.983 in.)

### Cylinder Bore Out of Round:

Standard ..... 0.056 mm (0.0004 in.)

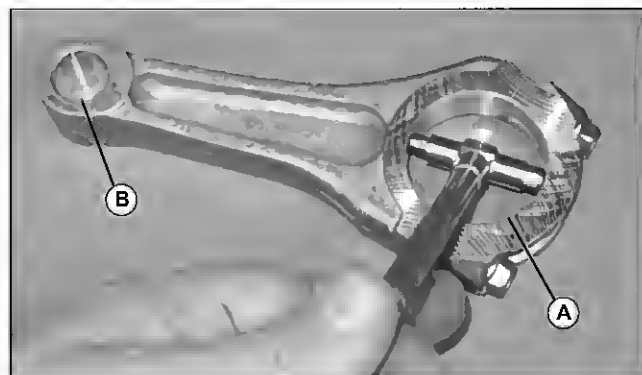
Wear Limit ..... 0.01 mm (0.002 in.)

If cylinder bore exceeds wear limit, rebore cylinder or replace cylinder block. See "Resize Cylinder Bore" on page 143.

**Note:** If cylinder is rebored, **oversize piston and rings must be installed.**

## Connecting Rod:

1. Clean and inspect rod. Replace if scored.
2. Install connecting rod cap. Tighten to **9.8 N•m (87 lb-in.)**.



MX36935

3. Measure connecting rod crankshaft bearing diameter (A) and piston pin diameter (B). Replace connecting rod if either measurement is greater than specifications.

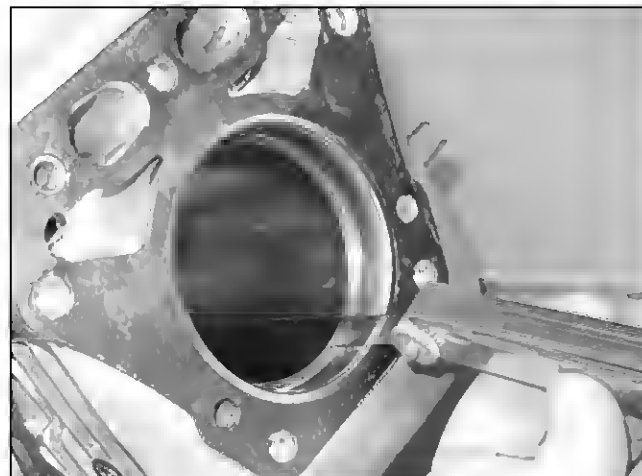
## Connecting Rod Bearing ID (Wear Limit):

Crankshaft Bearing ..... 38.06 mm (1.498 in.)

Piston Pin Bearing ..... 16.05 mm (0.632 in.)

## Piston Rings:

1. Measure thickness of top and second piston rings at several places. If thickness is less than **1.40 mm (0.055 in.)**, replace piston ring.



MX36936

2. Check piston ring end gap. Install each ring squarely in bore approximately **25.4 mm (1.0 in.)** down from top of cylinder.
3. Check end gap. Replace if end gap is greater than specifications.

# ENGINE - KAWASAKI (FH661V, FH721V) REPAIR

## End Gap Specifications:

### Maximum End Gap

Top Ring ..... 0.65 mm (0.026 in.)

Second Ring ..... 0.78 mm (0.031 in.)

Oil Control Ring (Side Rails) ..... 1.05 mm (0.041 in.)

## Analyze Crankshaft and Connecting Rod Wear

### Procedure:

Check connecting rod and cap for damage or unusual wear patterns.

Lack of lubrication or improper lubrication can cause the connecting rod and cap to seize the crankshaft.

When the rod and cap seize to the crankshaft, the connecting rod and piston may both break causing other internal damage. Inspect block carefully before rebuilding engine.

Crankshaft and connecting rod damage can result from:

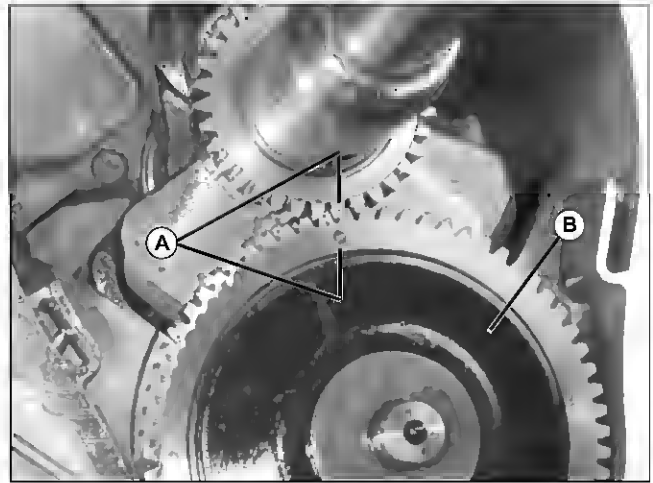
- Engine run low on oil or without oil.
- Oil not changed regularly.
- Bearing cap installed incorrectly.

## Camshaft and Tappets

### Removal:

1. Remove fuel pump.
2. Remove rocker arm assemblies.
3. Remove crankcase cover.
4. Position engine with cylinder heads down. This will allow gravity to hold the tappets in place.

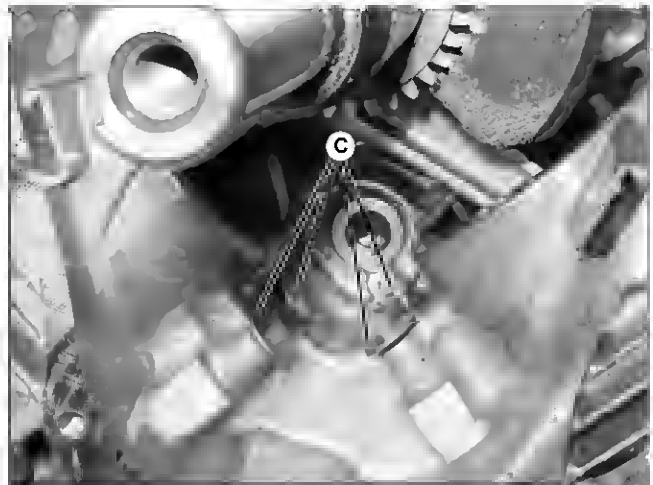
**Important: Avoid Damage! Align timing marks to prevent damage to tappets when removing camshaft.**



MX36937

5. Rotate crankshaft until timing marks (A) align.
6. Remove and inspect camshaft (B).

**Note: Mark tappets so they can be installed in their original guides during assembly.**



MX37384

7. Remove and inspect tappets (C) for wear or damage. Replace if necessary.

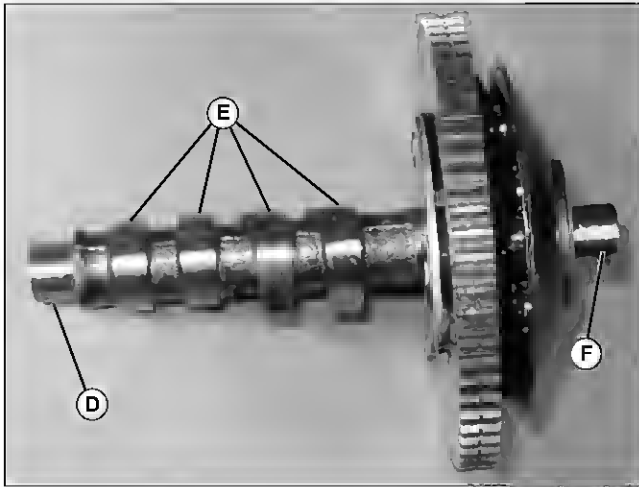
# ENGINE - KAWASAKI (FH661V, FH721V) REPAIR

Installation is done in the reverse order of removal.

- Align timing marks when installing camshaft.

## Inspection:

1. Inspect camshaft for worn or broken teeth.



MX37371

2. Measure PTO side journal (F), flywheel side journal (D) and lobes (E). Replace camshaft and tappets if any measurement is less than specifications.

## Camshaft Specifications (Minimum):

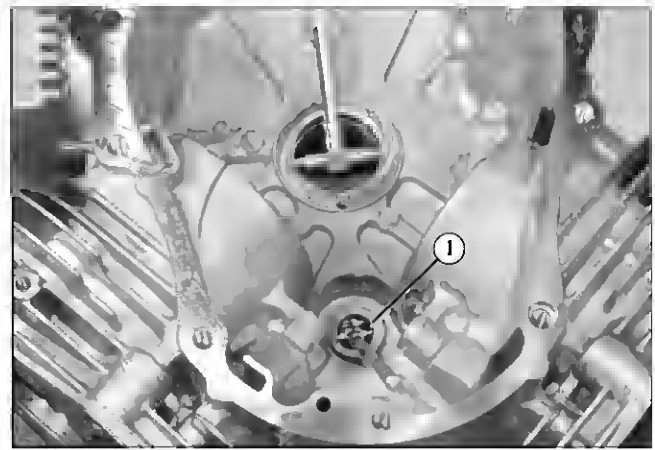
Side Journals . . . . . 15.98 mm (0.629 in.)

Cam Lobe Height . . . . . 29.62 mm (1.166 in.)



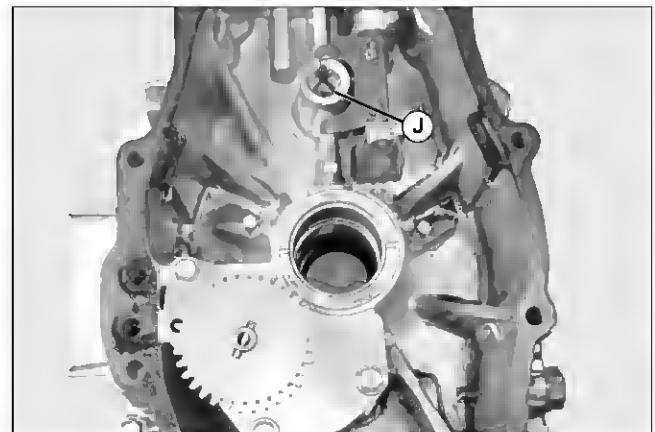
MX36938

3. Inspect Automatic Compression Release weight (H) for damage.
4. Inspect spring (G). Replace if worn or damaged.
5. Shake the camshaft assembly and check that the ACR weight (H) swings smoothly.



MX37373

Picture Note: Cylinder Block Bearing



MX37372

Picture Note: Crankcase Cover Bearing

6. Measure camshaft bearings in cylinder block (I) and crankcase cover (J). Replace block or cover if either diameter is greater than 16.13 mm (0.635 in.).

## Crankshaft and Main Bearings

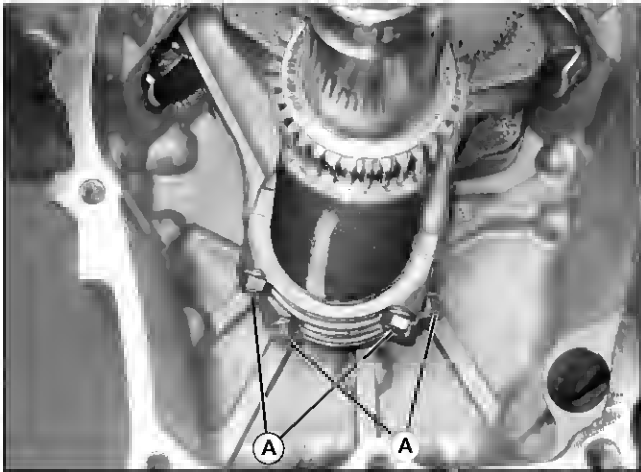
### Removal:

1. Remove flywheel and crankcase cover.
2. Remove camshaft.

**Important: Avoid Damage! Connecting rod caps must be installed on the same connecting rods they were removed from.**

3. Mark connecting rod caps to aid in installation.

# ENGINE - KAWASAKI (FH661V, FH721V) REPAIR



4. Remove connecting rod caps (A) and push pistons to top of cylinder.
5. Remove crankshaft.
6. Inspect crankshaft for wear or damage.

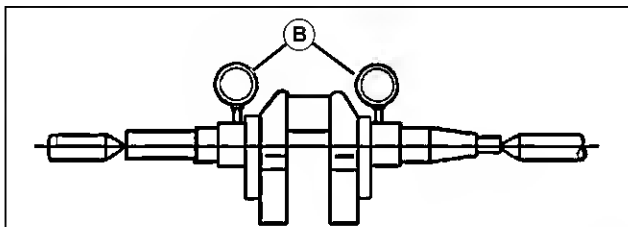
**Installation is done in the reverse order of removal.**

1. Cover keyway on flywheel end of crankshaft with tape to prevent seal damage when installing crankshaft.
2. Apply a light film of clean engine oil on crankshaft bearing surfaces before installation.
3. Pack oil seals with lithium base grease.
4. Install connecting rod caps and tighten to **9.8 N•m (87 lb-in.)**.

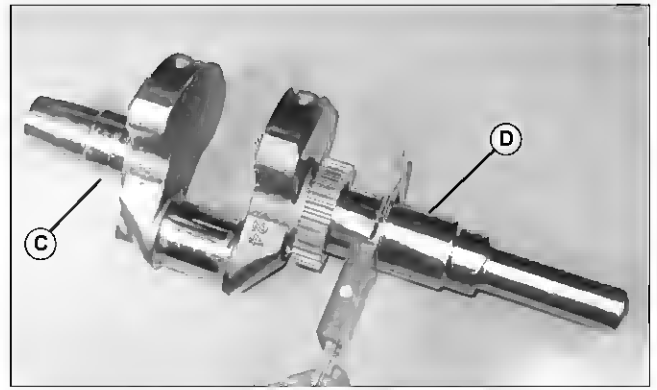
## Inspection:

**Important: Avoid Damage! A bent crankshaft must be replaced; it cannot be straightened.**

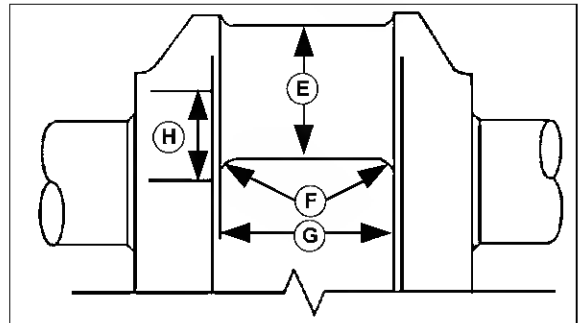
1. Clean and inspect crankshaft. Replace if scratched or damaged.



2. Place crankshaft into an alignment jig and slowly rotate crankshaft. Use dial indicators (B) to measure maximum Total Indicated Runout (TIR). If runout exceeds **0.05 mm (0.002 in.)**, replace crankshaft.



3. Measure main bearing journal diameters. If PTO side journal (D) OD is **less than 39.89 mm (1.571 in.)** replace crankshaft. If flywheel side journal (C) OD is **less than 39.89 mm (1.571 in.)** replace crankshaft.



4. Measure connecting rod journal diameter (E) and inspect journal radii (F) for cracks. Connecting rod journal can be resized to accept undersized rod. Have grinding done by a reliable repair shop.

If undersized journal diameter is less than specifications, replace crankshaft.

## Connecting Rod Journal OD (Wear Limit):

**Standard** ..... **37.94 mm (1.494 in.)**

## Resizing Specifications:

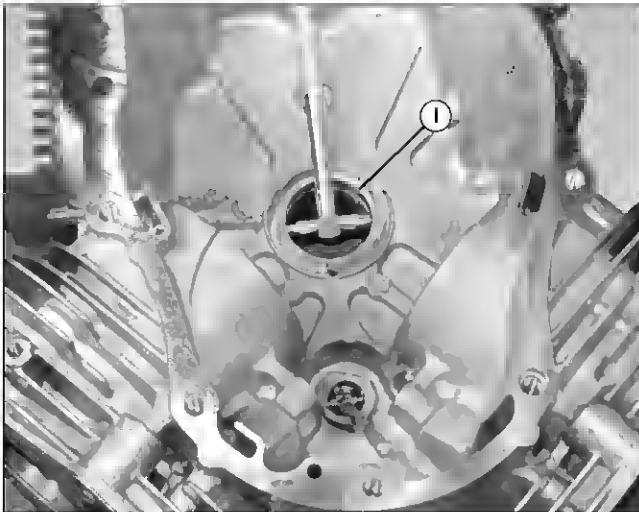
**E.** ..... **37.46 - 37.47 mm (1.474 - 1.475 in.)**

**F.** ..... **2.0 - 2.4 mm (0.078 - 0.094 in.)**

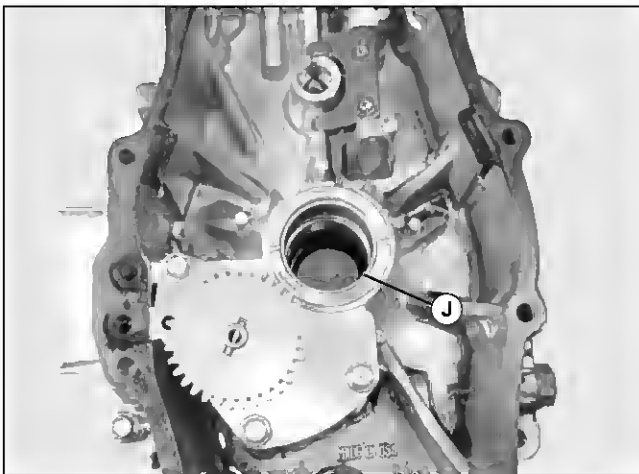
**G (Maximum)** ..... **43 mm (1.693 in.)**

**H.** ..... **37.95 - 38.05 mm (1.494 - 1.498 in.)**

# ENGINE - KAWASAKI (FH661V, FH721V) REPAIR



Picture Note: Cylinder Block Bearing



Picture Note: Crankcase Cover Bearing

5. Measure crankshaft main bearing diameter in crankcase (I) and crankcase cover (J). Replace crankcase cover or crankcase if diameter is greater than **40.15 mm (1.581 in.)**.

## Specification:

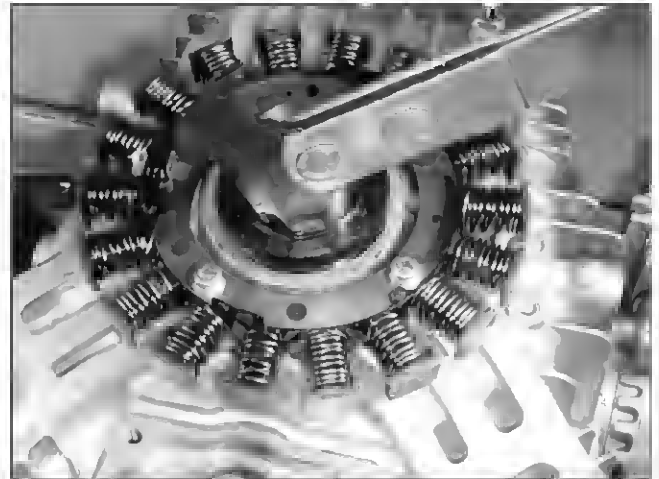
**Connecting Rod Journal OD Wear Limit (E) . 37.94 mm (1.494 in.)**

## Crankshaft Oil Seals

*Note: Oil seals can be replaced with crankshaft installed. Make sure oil seal removal tool does not contact crankshaft. If engine is disassembled, simply pry out seals with a large screwdriver and install new ones with a seal driver.*

### Replacement (Flywheel End):

1. Remove blower housing, fan, and flywheel.



2. Using care not to contact crankshaft or coils on stator, pry seal out of bore.
3. Apply lithium based grease inside lips of new seal. Install seal with lip toward inside of engine. Using a seal driver, install seal flush with top of bore.

### Replacement (PTO End):

1. Remove clutch and sheave assemblies. Remove engine from machine.



2. Using care not to contact crankshaft, pry seal out of crankcase cover

# ENGINE - KAWASAKI (FH661V, FH721V) REPAIR

3. Apply lithium based grease inside lips of new seal.
4. Install seal with lip toward inside of engine using a seal driver. Press in seals until flush with flange surface.

## Deglaze Cylinder Bore

### Procedure:

1. Deglaze cylinder bore using a rigid hone with a 220 to 300 grit stone.
2. Use hone as instructed by manufacturer to obtain 45° crosshatch pattern.

**Important: Avoid Damage! Do not use gasoline, kerosene, or commercial solvent to clean cylinder bores. Solvents will not remove all abrasives from cylinder walls.**

3. Clean cylinder walls using clean white rags and warm soapy water. Continue to clean cylinder until white rags show no discoloration.

## Resize Cylinder Bore

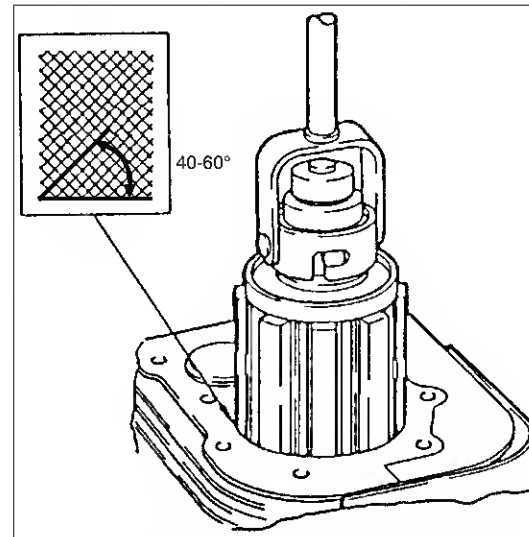
### Procedure:

**Important: Avoid Damage! Check stone for wear or damage. Use correct stone for the job.**

The cylinder block can be resized to use **0.50 mm (0.020 in.)** oversize pistons and rings. Have a reliable repair shop resize the block, or use the drill press and honing tool. Resize cylinder with a honing tool to initial and final bore specifications.

1. Align center of bore to drill press center.
2. Lower and raise hone until ends extend **20 - 25 mm (0.75 - 1.0 in.)** past ends of cylinder.
3. Adjust hone so lower end is even with end of cylinder bore.
4. Adjust rigid hone stones until they contact narrowest point of cylinder.
5. Coat inside of cylinder with honing oil. Turn hone by hand. Adjust if too tight.
6. Run drill press between 200 - 250 rpm. Move hone up and down in cylinder approximately 20 times per minute.

**Note: Measure bore when cylinder is cool.**



M82412A

7. Stop press and check cylinder diameter.

**Note: Finish should not be smooth, but have a 40 - 60° cross-hatch pattern.**

8. Check bore for size, taper, and out-of-round.
9. Hone the cylinder an additional **0.006 - 0.008 mm (0.0002 - 0.0003 in.)** for final bore specifications. This allows for shrinkage when cylinder cools.

**Important: Avoid Damage! DO NOT use gasoline or commercial solvents to clean cylinder bores. Solvents will not remove metal particles produced during honing**

10. Clean the cylinder thoroughly using soap, warm water and clean rags. Continue to clean cylinder until white rags show no discoloration.

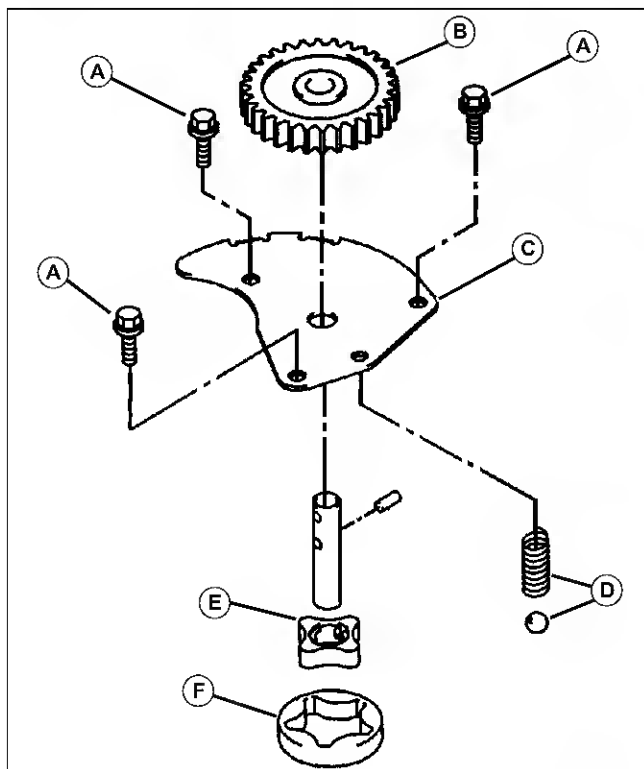
11. Dry the cylinder. Apply engine oil to cylinder wall.

# ENGINE - KAWASAKI (FH661V, FH721V) REPAIR

## Oil Pump Disassembly and Assembly

### Disassembly:

1. Remove crankcase cover. See "Crankcase Cover Removal and Installation" on page 134.



M95415

2. Remove the three mounting cap screws (A) and lift the oil pump gear and shaft assembly (B) and cover plate (C) out of the crankcase.
3. Remove relief valve spring and ball (D).
4. Remove the inner (E) and outer (F) rotors.
5. Inspect all parts for wear or damage.

### Assembly is done in the reverse order of disassembly.

1. Fill rotor housing with engine oil for initial lubrication.
2. Install the outer (F) and inner (E) rotors.
3. Install relief valve ball and spring (D).
4. Install oil pump gear and shaft assembly (B), cover plate (C), and secure with three cap screws (A).
5. Tighten the three cap screws (A) to **6.9 N•m (61 lb-in.)**.

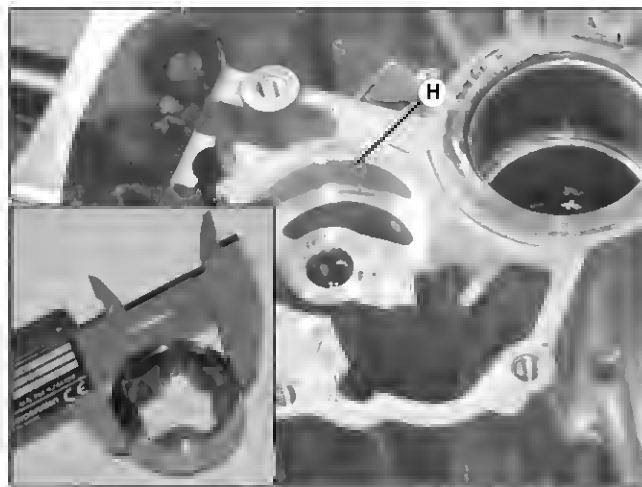
### Inspection:

Inspect all parts for wear or damage. Replace as necessary.



MX37378, MX37377

1. Measure rotor shaft diameter. If shaft OD is less than **10.92 mm (0.430 in.)**, replace shaft.
2. Measure rotor shaft bearing (G). If bearing ID is greater than **11.07 mm (0.436 in.)**, replace crankcase cover.

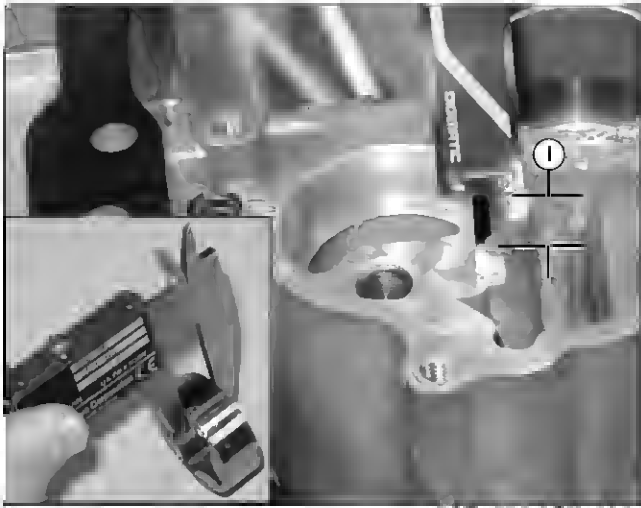


MX37379, MX37377

3. Measure outside diameter of outer rotor. If OD is less than **40.47 mm (1.593 in.)**, replace outer rotor.
4. Measure inside diameter of rotor housing (H). If ID is greater than **40.80 mm (1.606 in.)**, replace crankcase cover.

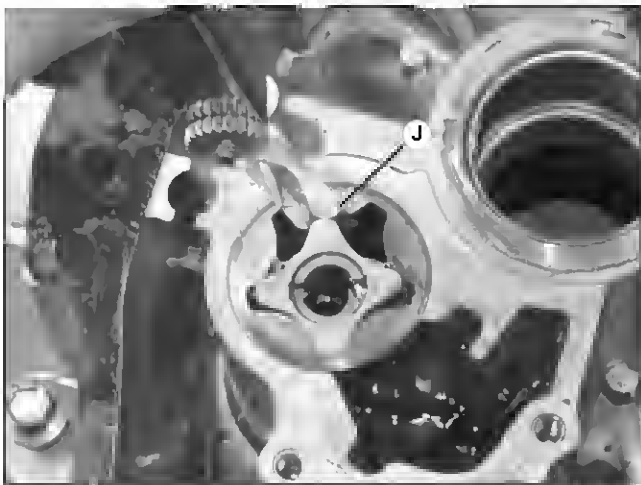


# ENGINE - KAWASAKI (FH661V, FH721V) REPAIR



MX37380, MX37381

5. Measure thickness of outer rotor. If thickness is less than **9.83 mm (0.387 in.)**, replace rotor.
6. Measure outer rotor housing depth (I). If depth is greater than **10.23 mm (0.403 in.)**, replace crankcase cover.



MX37376

7. Measure inner-to-outer rotor clearance (J) with a feeler gauge. If clearance is greater than **0.2 mm (0.008 in.)**, replace both rotors.



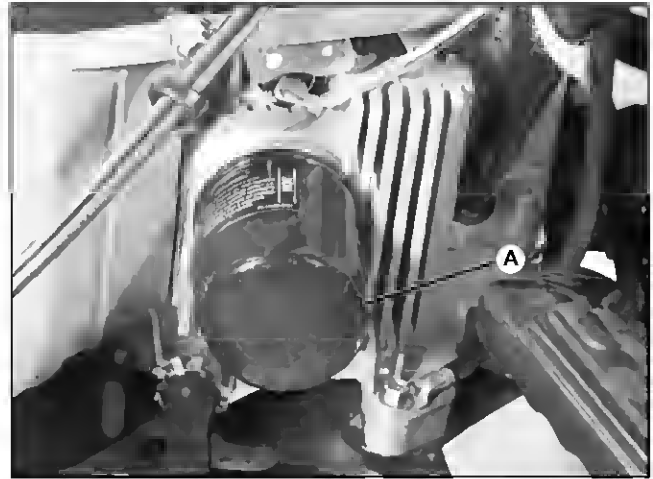
M50083

8. Measure relief valve spring. If free length is less than **19.50 mm (0.768 in.)**, replace spring.

## Oil Cooler Removal and Installation

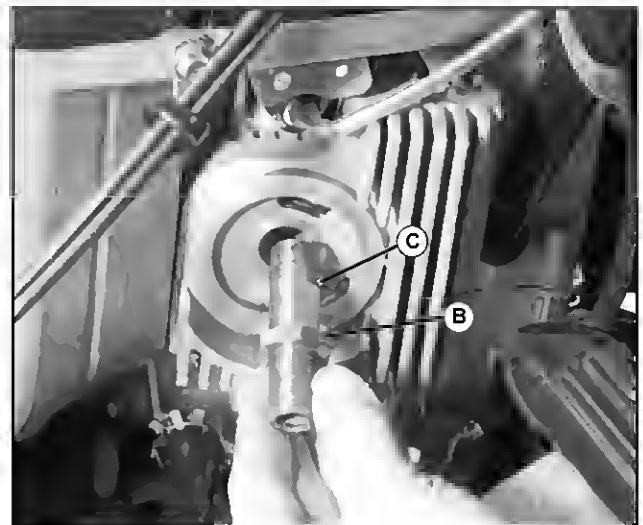
### Removal:

1. Park machine safely.



MX37052

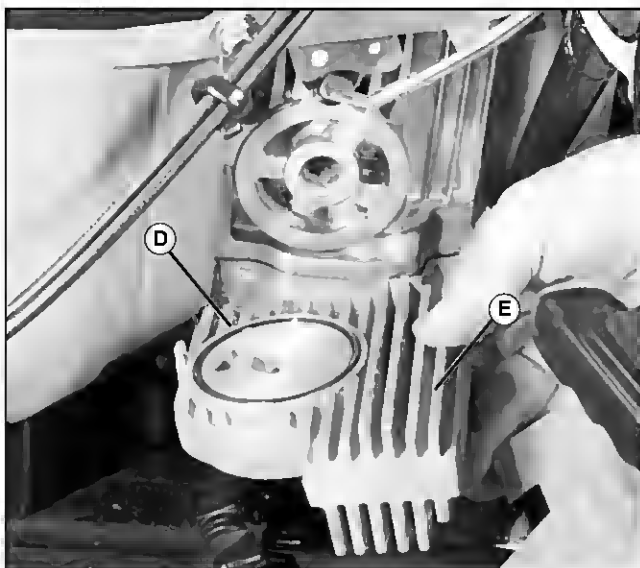
2. Remove oil filter (A)



MX37054

3. Remove oil filter adaptor (B). Note long end (C) goes through cooler and into block.

# ENGINE - KAWASAKI (FH661V, FH721V) REPAIR



4. Remove oil cooler (E) and O-ring gasket (D). Inspect and replace gasket if damaged.

## Installation:

Installation is done in reverse order of removal.

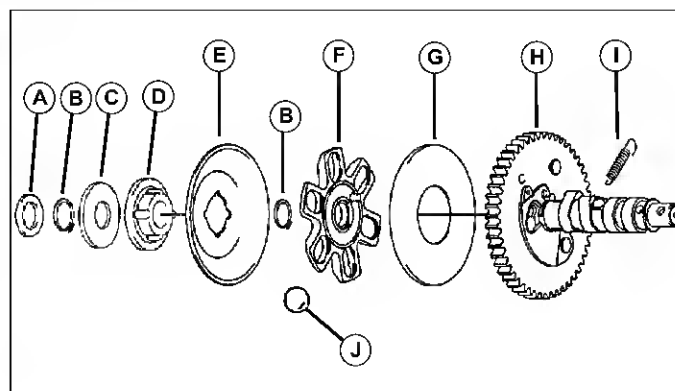
## Governor Inspection and Replacement

### Procedure:

1. Remove crankcase cover. See "Crankcase Cover Removal and Installation" on page 134.
2. Remove rocker covers and push rods.



3. Turn engine upside down and remove camshaft (G).



- A- Washer
- B- Snap Ring
- C- Washer (FH721 engines only)
- D- Sleeve
- E- Governor Plate
- F- Ball Guide
- G- Ball Plate
- H- Camshaft
- I- Automatic Compression Release Spring
- J- Steel Balls (6)

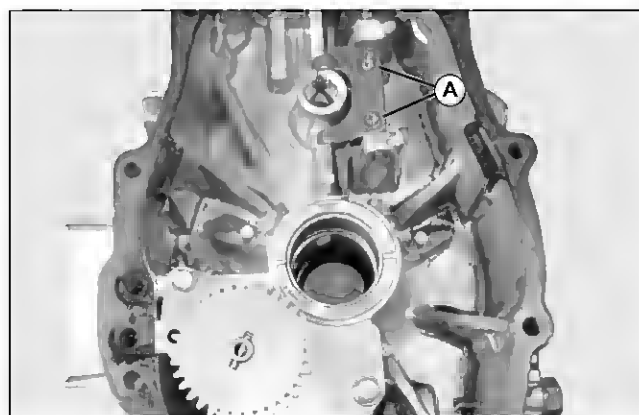
4. Disassemble the governor assembly from the camshaft.
5. Inspect governor for wear or damage. Replace if necessary.
6. When assembling, be sure the steel balls are seated in slots on the ball guide and that the snap rings are fully seated in their grooves.

## Governor Shaft Inspection and Replacement

### Removal:

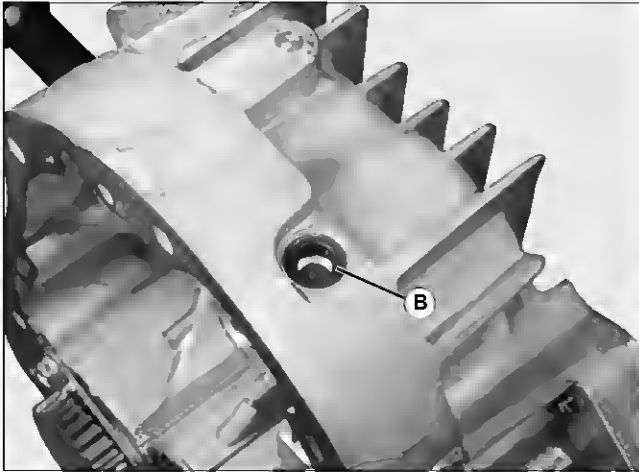
**Note: It is not necessary to remove governor shaft unless damaged.**

1. Remove crankcase cover. See "Crankcase Cover Removal and Installation" on page 134.



# ENGINE - KAWASAKI (FH661V, FH721V) REPAIR

2. Unscrew the governor shaft plate screws (A) and pull the governor shaft out of the crankcase cover.



MX37372

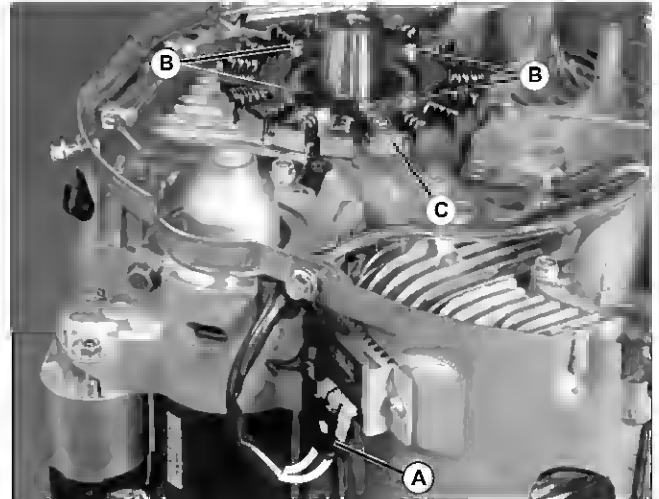
3. Replace the oil seal (B) if the lip shows signs of leakage or it has been damaged.
4. Inspect governor shaft for wear or damage. Replace if necessary.

## Installation:

1. Apply clean engine oil to the governor shaft.
2. Insert the governor shaft into the crankcase.
3. Install the governor shaft plate to the shaft and tighten the screws to **2.0 N•m (17 lb-in.)**.
4. Check that governor shaft turns freely within its operating range.
5. If oil seal has been removed, press a new seal into crankcase with the seal lip to the inside.
6. Press the seal in to flush to **1.0 mm (0.04 in.)** below crankcase surface.

## Stator Removal and Installation

### Removal:



MX37385

1. Remove blower housing and flywheel.
2. Disconnect stator lead (A).
3. Remove screws (B) and stator (C).

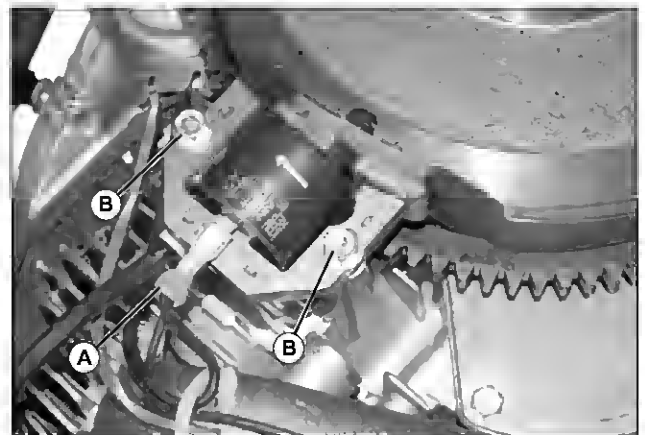
### Installation:

Installation is done in the reverse order of removal.

## Armature Removal and Installation

### Removal:

1. Remove blower housing.



MX36428

2. Disconnect wire (A) from coil.
3. Remove cap screws (B) and armature with coil.
4. Replace as needed.

Installation is done in the reverse order of removal.

1. Adjust armature air gap. See "Ignition Coil Air Gap"

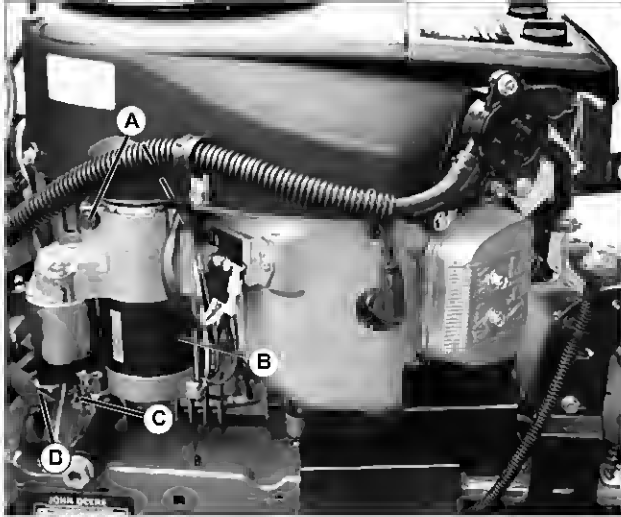
# ENGINE - KAWASAKI (FH661V, FH721V) REPAIR

Adjustment" on page 116.

## Starting Motor Removal and Installation

### Removal:

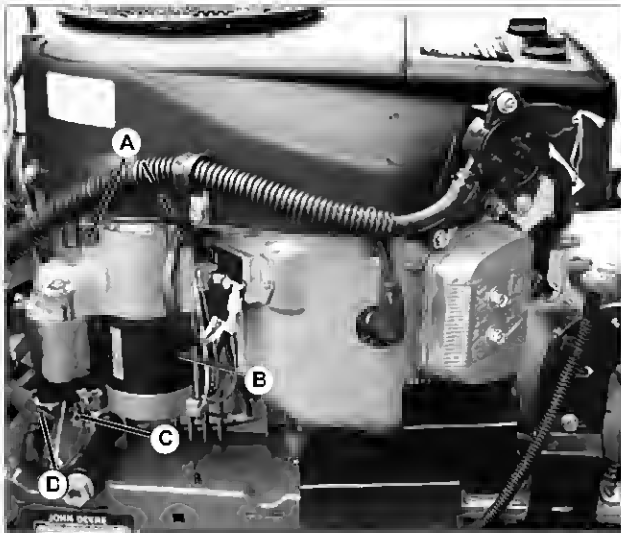
1. Disconnect negative (-) battery terminal.



MX16330

2. Disconnect positive (+) battery cable and orange wire from large terminal (D) of starter solenoid. Disconnect purple wire (C) from solenoid.
3. Remove two cap screws (A) and starter assembly (B).

### Installation:



MX16330

1. Install starter assembly (B) and secure with two cap screws (A). Tighten two cap screws (A) to **15 N•m (132 lb-in.)**.
2. Connect positive (+) battery cable and orange wire to large terminal (D) of starter solenoid. Tighten nut securing wires to **9.8 N•m (84 lb-in.)**. Connect purple wire (C) to

solenoid.

3. Connect negative (-) battery terminal.

## Starting Motor Disassembly and Assembly

### Analyze Condition:

The starting motor overheats because of:

- Long cranking.
- Armature binding.

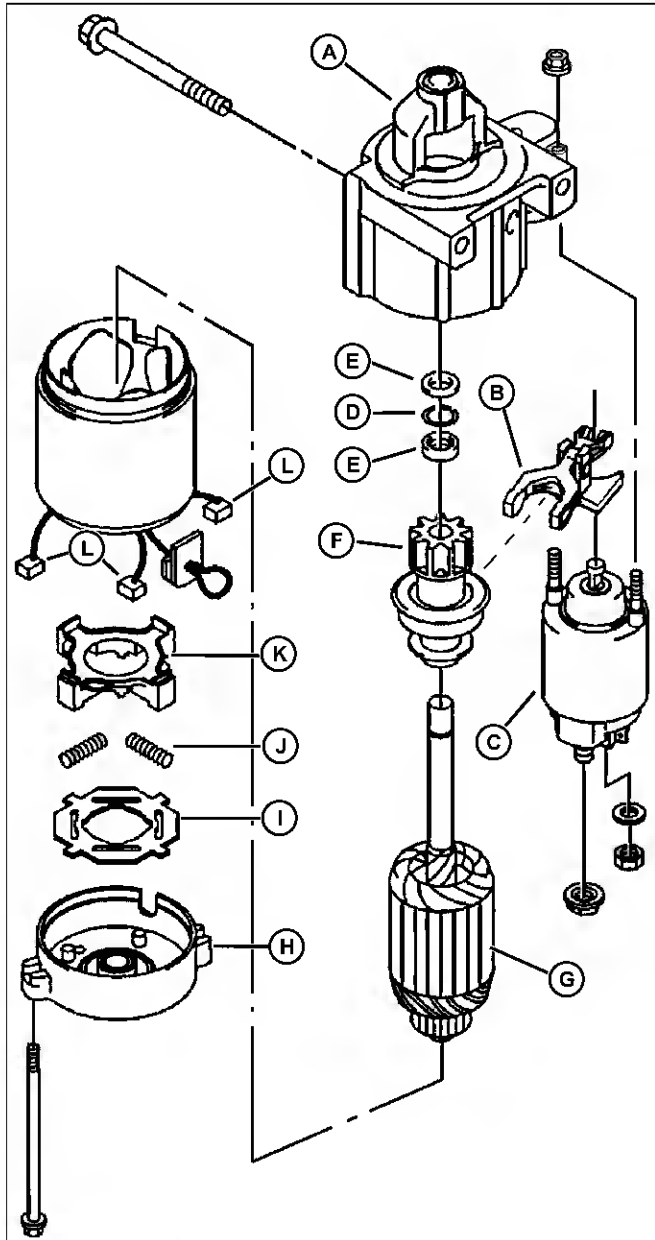
The starting motor operates poorly because of:

- Armature binding.
- Dirty or damaged starting motor drive.
- Badly worn brushes or weak brush springs.
- Excessive voltage drop in cranking system.
- Battery or wiring defective.
- Shorts, opens, or grounds in armature.

**Note:** Starting motor repair is limited to brushes, end caps, and starting motor drive. Fields in starting motor are permanent magnets and are not serviceable. If housing or armature is damaged, replace starting motor.

# ENGINE - KAWASAKI (FH661V, FH721V) REPAIR

## Disassembly and Assembly:



- A- Front Cover
- B- Shift Lever
- C- Solenoid
- D- Retaining Clip
- E- Pinion Stopper
- F- Pinion
- G- Armature
- H- End Cover
- I- Insulator
- J- Brush Springs
- K- Brush Holder
- L- Brush

1. Mark body and covers for correct alignment during reassembly.
2. Push pinion stopper (E) toward pinion (F) to remove retaining clip (D).
3. Inspect parts for wear or damage.
4. Test solenoid (C), starting motor armature (G) and brushes (O). (See Inspection/Test procedures.)

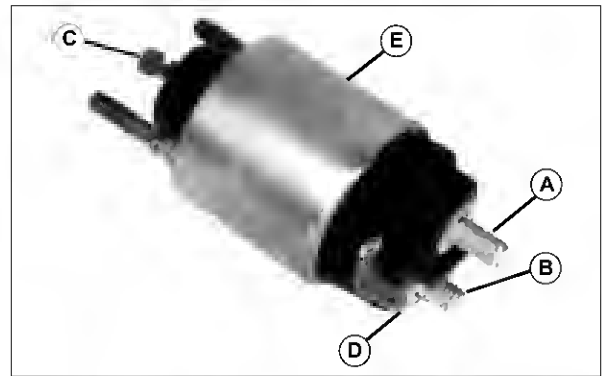
**Assembly is done in the reverse order of disassembly.**

Apply a thin coat of multipurpose grease to:

- Sliding surfaces of armature and solenoid shift lever.
- Armature shaft spline.
- Points where shaft contacts cover.

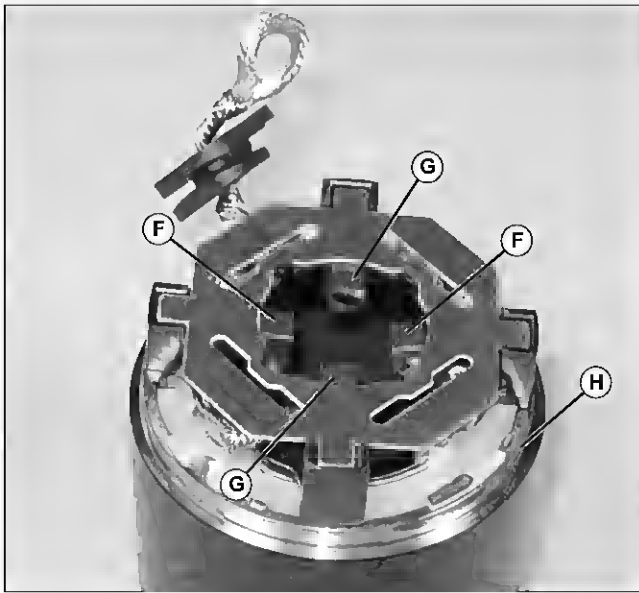
## Inspection/Test:

1. Measure field coil brush lengths. If any one brush length is less than **6.4 mm (0.250 in.)**, replace all four brushes.
2. Inspect brush springs for wear or damage. Replace if necessary.



3. Test solenoid terminals (A and B) for continuity. There should be no continuity.
4. Depress switch arm (C). There should be continuity when arm is fully depressed.
5. Test for open circuits between terminal (B) and tang (D). There should be continuity.
6. Test for open circuits between tang (D) and body (E). There should be continuity.
7. If solenoid fails any test, it is defective and must be replaced.

# ENGINE - KAWASAKI (FH661V, FH721V) REPAIR

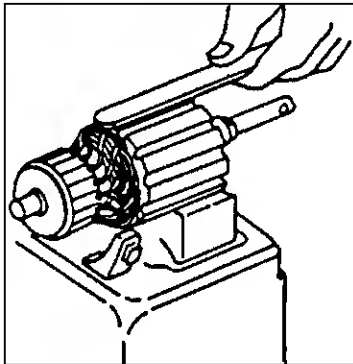


## 8. Test case with field windings and brushes:

- Test for open circuits between brushes (F), then (G) for continuity. There should be continuity.
- Check either brush (F) to non-painted area of case (H) for continuity. There should be no continuity.
- Check either brush (G) to non-painted area of case (H) for continuity. There should be continuity.

## 9. Replace the case assembly if it fails any test.

**Important: Avoid Damage! Do not clean armature with solvent. Solvent can damage insulation on windings. Use only mineral spirits and a brush.**

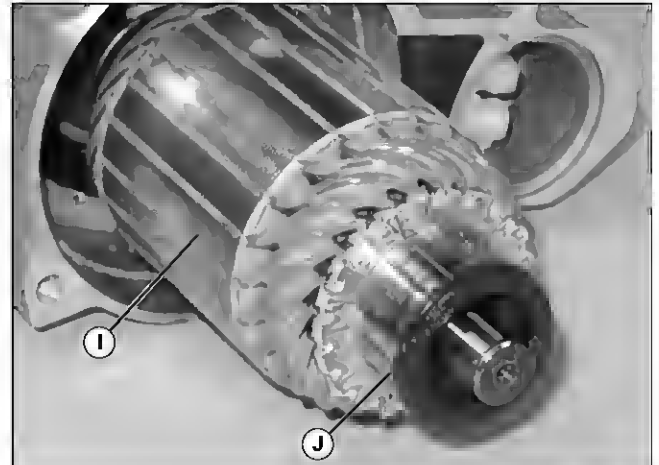


10. Locate short circuits by rotating armature on a growler while holding a hacksaw blade or steel strip on armature. The hacksaw blade will vibrate in area of short circuit.

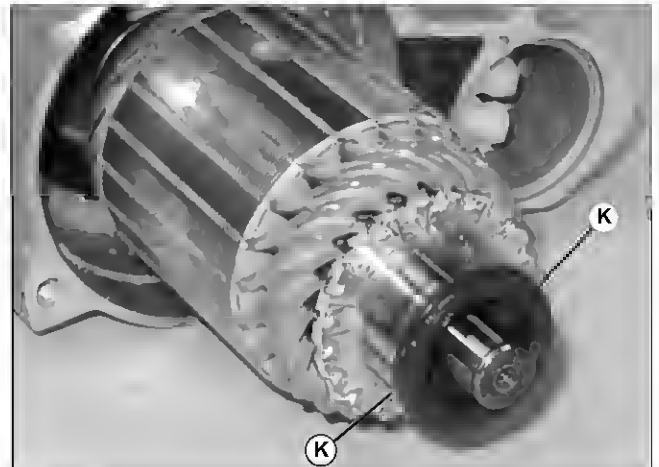
**Note: Shorts between bars are sometimes caused by dirt or copper between bars. Inspect for this condition.**

11. If test indicates short circuited windings, clean the commutator of dust and fillings. Check armature again. If

test still indicates short circuit, replace armature.



12. Test for grounded windings using an ohmmeter. Hold one probe on the armature stack (I) and then touch the other probe on each commutator bar (J). Armature windings are connected in parallel, so each commutator bar needs to be checked. If test shows continuity, a winding is grounded and the armature must be replaced.



13. Test for open circuited windings using an ohmmeter. Touch probes on each set of commutator bar 180° apart (K). If test shows no continuity, replace the armature.

# ENGINE - KAWASAKI (FH661V, FH721V) REPAIR

## No-Load Amperage Draw and RPM Test

### Reason:

To determine if starting motor is binding or has excessive amperage draw under no-load.

### Test Equipment:

- JT05791 Multitester
- JTO2153 Current Clamp
- Photo Tachometer
- 12 Volt Battery
- JTO7270 Hand-Held Digital Tachometer
- Jumper Cables
- Jumper Wire (To connect the starting motor positive post and the solenoid shift connector)

### Procedure:

**Important: Avoid Damage! Complete this test in 20 seconds or less to prevent starting motor damage.**

**Note: Check that battery is fully charged and of proper size to ensure accuracy of test.**

1. Park machine safely.
2. Remove starting motor.
3. Clamp the starting motor mounting bracket in a vise.
4. Connect the NEG jumper cable to the battery NEG post

and the frame of the starting motor.

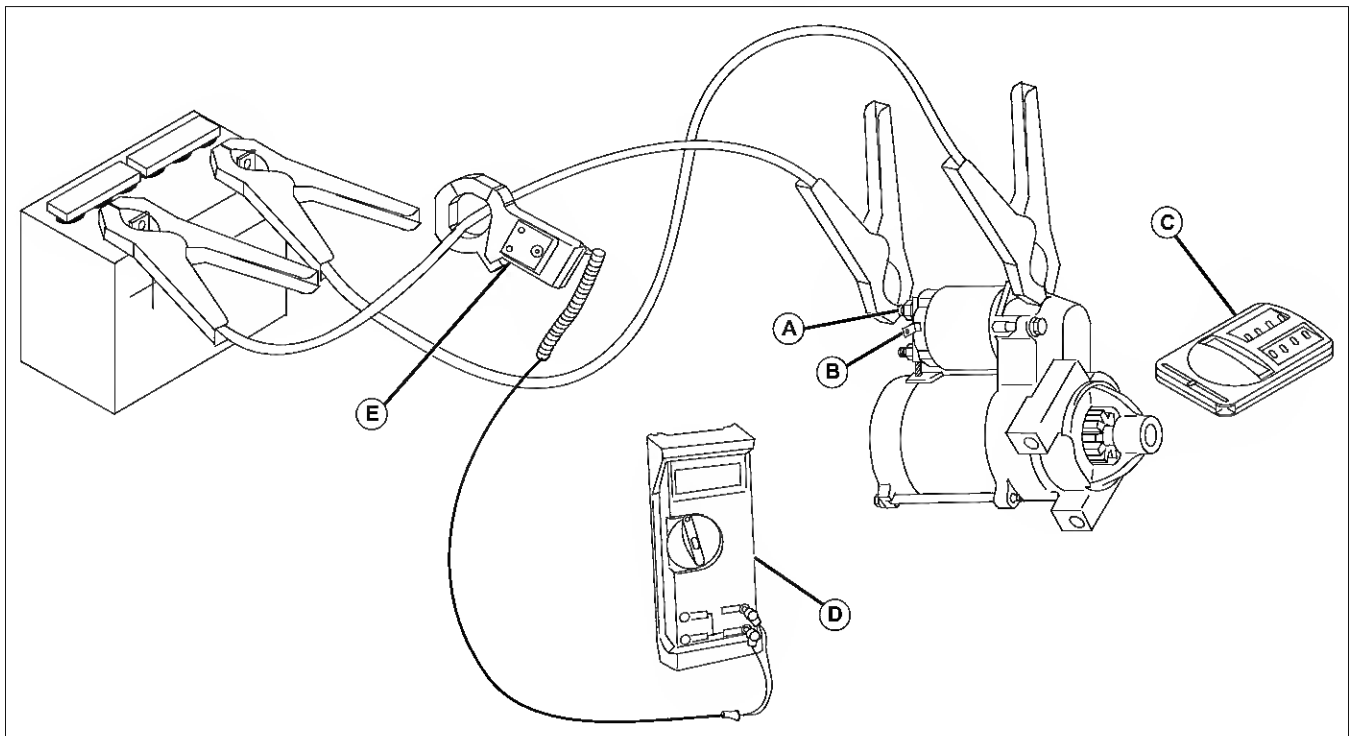
5. Connect the POS jumper cable to the POS post of the battery.
6. Connect current clamp RED lead to the VOLTS jack of the multitester and the BLACK lead of the current clamp to the COM jack on the multitester.
7. Clamp jaws of current clamp (E) around the positive jumper cable.

**Note: Adjust the DCA Zero Adjust dial on the current clamp for a zero reading on the multitester. The core of the jaws may hold some magnetic force after the current clamp has been used for measurement. If you cannot adjust the display to zero, open the jaws and snap them closed several times.**

8. Set the current clamp to 2000A and the multitester (D) to 300mV.

**Important: Avoid Damage! Connect the POS jumper cable lead to the starting motor POS post (A).**

9. Momentarily connect the starting motor POS post (A), to the starting motor solenoid shift connector (B), and read the starting motor amperage draw.
10. Disconnect and remove the current clamp (E).
11. Place a piece of reflective tape on the starting motor gear shaft.
12. Momentarily touch the POS jumper cable lead to the starting motor POS post and read the starting motor rpm.



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## ENGINE - KAWASAKI (FH661V, FH721V) REPAIR

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13. Momentarily touch the POS jumper cable lead to the starting motor POS post and read the starting motor rpm.

### Results:

- A good starting motor should have a maximum amperage reading of 50 amps and a minimum reading of 5000 rpm.
- If amperage or starting rpm is not within specification, check for binding or seized bearings, sticky brushes, and dirty or worn commutator. Repair or replace starting motor.



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# ENGINE - KAWASAKI (FS541V) TABLE OF CONTENTS

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# ENGINE - KAWASAKI (FS541V) SPECIFICATIONS

## Specifications

### General Specifications

#### General Specifications:

Make	Kawasaki V-Twin
Model Number	FS541V
Bore	73 mm (2.87 in.)
Stroke	72 mm (2.84 in.)
Displacement	603 cm <sup>3</sup> (36.8 cu in.)
Cylinders	2 (V-Twin)
Stroke Cycle	4
Valves	Overhead
Lubrication	Fully Pressurized
Oil Capacity w/ Oil Filter	1.7 L (1.8 qt)
Oil Filter	Full Flow, Spin-On
Cooling System	Forced Air
Muffler	Horizontal Discharge Below Frame
Spark Plug	NGK BPR4ES
Spark Plug Gap	0.76 mm (0.030 in.)
Spark Plug Torque	22 N•m (195 lb-in.)

### Test and Adjustment Specifications

#### Test and Adjustment Specifications:

Governed Low Idle	1850 ± 150 rpm
Fast Idle	3100 ± 100 rpm
Low Speed Carb Idle Screw	1450 ± 150 rpm
Ignition Coil Air Gap	0.2 - 0.4 mm (0.008 - 0.016 in.)
Oil Pressure @ 3200 rpm	294 - 686 kPa (43 - 99 psi)
Crankcase Vacuum	1.3 - 25.4 cm (0.5 - 10.0 in.)
Cylinder Compression (Minimum)	448 kPa (64 psi)
Valve Clearance (Intake and Exhaust) (Cold)	0.10 - 0.15 mm (0.004 - 0.006 in.)
Fuel Pump Pressure (Slow Idle)	2.45 kPa (0.36 psi)
Minimum Fuel Flow	65 mL (2.2 oz)/15 seconds

### Repair Specifications

#### Cylinder Head:

Cylinder Head Distortion (Maximum)	0.05 mm (0.002 in.)
Valve Guides ID	6.00 - 6.01 mm (0.0236 - 0.237 in.)
Valve Guides ID (Maximum)	6.08 mm (0.239 in.)
Valve Seat Width	0.8 - 1.4 mm (0.031 - 0.055 in.)
Valve Spring Free Length	31.0 mm (1.22 in.)

#### Intake and Exhaust Valves:

Valve Clearance (Intake and Exhaust) (Cold)	0.10 - 0.15 mm (0.004 - 0.006 in.)
Valve Stem OD (Intake) (Minimum)	5.95 mm (0.234 in.)

# ENGINE - KAWASAKI (FS541V) SPECIFICATIONS

Valve Stem OD (Exhaust) (Minimum) .....	5.93 mm (0.233 in.)
Valve Stem Bend (Maximum).....	0.05 mm (0.002 in.)
Valve Guide ID (Standard) .....	6.00 - 6.012 mm (0.236 - 0.237 in.)
Valve Guide ID (Maximum).....	6.08 mm (0.239 in.)
Valve Seating Surface (Standard).....	0.8 - 1.4 mm (0.031 - 0.055 in.)
Valve Seat and Face Angle .....	45°
Valve Margin (Minimum) .....	0.35 mm (0.014 in.)
Valve Seat Narrowing Angle .....	32°

## Piston Assembly:

Piston Ring Side Clearance (Top Ring) .....	0.12 mm (0.0047 in.)
Piston Ring Side Clearance (Second Ring) .....	0.12 mm (0.0047 in.)
Piston Ring Side Clearance (Oil Ring) .....	.Not Measured
Piston Ring Thickness (Top and Second) .....	1.1 mm (0.043 in.)
Piston Ring End Gap Maximum (Top Ring) .....	0.70 mm (0.028 in.)
Piston Ring End Gap Maximum (Second Ring).....	0.9 mm (0.035 in.)
Piston Ring End Gap Maximum (Oil Ring).....	1.05 mm (0.041 in.)
Piston Pin OD (Minimum) .....	15.96 mm (0.628 in.)
Piston Pin Bore OD (Maximum) .....	16.08 mm (0.633 in.)
Piston OD (Standard Minimum).....	72.79 mm (2.866 in.)
Piston OD (Oversize 0.50 mm (0.020 in.) .....	73.29 mm (2.886 in.)
Cylinder Bore ID (Standard).....	72.98 - 73.00 mm (2.873 - 2.874 in.)
Cylinder Bore ID (Wear Limit) .....	73.10 mm (2.878 in.)
Cylinder Bore ID (Oversize 0.50 mm (0.020 in.) .....	73.48 - 73.50 mm (2.893 - 2.894 in.)
Cylinder Bore ID (Oversize 0.50 mm (0.020 in.) (Wear Limit) .....	73.60 mm (2.898 in.)
Cylinder Bore Out Of Round (Wear Limit) .....	0.05 mm (0.002 in.)

## Connecting Rod:

Crankshaft Bearing ID (Maximum) .....	38.04 mm (1.5 in.)
Piston Pin Bearing ID (Maximum).....	16.05 mm (0.632 in.)

## Crankshaft:

Crankpin Width (Maximum).....	40.0 mm (1.57 in.)
Crankpin OD (Minimum) .....	37.94 mm (1.49 in.)
Journal Diameter (PTO Side) (Minimum) .....	37.90 mm (1.492 in.)
Journal Diameter (Flywheel Side) (Minimum) .....	34.90 mm (1.374 in.)
Crankcase Cover PTO Shaft ID (Maximum) .....	38.10 mm (1.5 in.)
Crankcase Crankshaft Journal Bearing ID (Maximum).....	35.10 mm (1.382 in.)

## Camshaft:

Lobe Height (Intake and Exhaust) (Minimum) .....	29.62 mm (1.166 in.)
Journal Diameter (PTO and Flywheel) (Minimum).....	15.99 mm (0.630 in.)
Bearing ID (Crankcase and Cover) (Maximum) .....	16.14 mm (0.635 in.)

# ENGINE - KAWASAKI (FS541V) SPECIFICATIONS

## Oil Pump:

Outer Rotor OD (Minimum) .....	52.31 mm (2.059 in.)
Outer Rotor Housing ID (Maximum) .....	52.72 mm (2.076 in.)
Outer Rotor Thickness (Minimum) .....	14.91 mm (0.587 in.)
Inner and Outer Rotor Clearance (Maximum) .....	0.2 mm (0.008 in.)
Pump Housing Depth (Maximum) .....	15.16 mm (0.596 in.)
Spring Free Length (Minimum) .....	20.4 mm (0.803 in.)

## Starting Motor:

Maximum Amperage (No Load) .....	50 amps @ 6000 rpm
Brush Length (Minimum) .....	10.16 mm (0.4 in.)

## Torque Specifications

### Torque Specifications:

Breather Cover Cap Screws .....	5.9 N•m (52 lb-in.)
Carburetor Mounting Stud Nut .....	5.9 N•m (52 lb-in.)
Clutch Cap Screw .....	75 N•m (55 lb-ft)
Connecting Rod Cap Screw .....	9.8 N•m (87 lb-in.)
Cooling Shroud Mounting Cap Screws .....	8.8 N•m (78 lb-in.)
Cylinder Head Cap Screws (Initial Torque) .....	13 N•m (115 lb-in.)
Cylinder Head Cap Screws (Final Torque) .....	27.4 N•m (20 lb-ft)
Crankcase Cover Mounting Cap Screws .....	27.4 N•m (20 lb-ft)
Engine Mounting Cap Screws .....	34 N•m (25 lb-ft)
Exhaust Pipe Nuts .....	22 N•m (16 lb-ft)
Fan Housing Cap Screws .....	8.8 N•m (78 lb-in.)
Flywheel Cap Screw .....	56 N•m (41 lb-ft)
Fuel Pump Mounting Cap Screws .....	5.9 N•m (52 lb-in.)
Fuel Solenoid to Carburetor .....	4.5 N•m (40 lb-in.)
Governor Arm Clamp Nut .....	7.8 N•m (69 lb-in.)
Governor Shaft Plate Screws .....	2.0 N•m (18 lb-in.)
Ignition Coil Cap Screws .....	5.9 N•m (52 lb-in.)
Intake Manifold Cap Screws .....	5.9 N•m (52 lb-in.)
Oil Plug .....	6.9 N•m (61 lb-in.)
Oil Pump Cover Cap Screws .....	5.9 N•m (52 lb-in.)
Rocker Arm Bracket Bolts .....	14.7 N•m (130 lb-in.)
Rocker Cover Cap Screws .....	5.9 N•m (52 lb-in.)
Spark Plug Torque .....	22 N•m (16 lb-ft)
Starting Motor Mounting Cap Screws .....	19.6 N•m (173 lb-in.)
Stator Coil Cap Screws .....	3.4 N•m (30 lb-in.)
Valve Adjusting Lock Nut .....	11N•m (97 lb-in.)

# ENGINE - KAWASAKI (FS541V) SPECIFICATIONS

## Tools

**Note:** Order tools according to information given in the U.S. SERVICE-GARD™ Catalog or in the European Microfiche Tool Catalog (MTC).

### Special or Required Tools

Tool Name	Tool No.	Tool Use
Hand-Held Digital Tachometer	JT05719	Used to check idle speed and starter performance.
Digital Pulse Tachometer	JT07270	Used to check idle speed .
Compression Gauge	JDM59	Used to check engine compression.
U-Tube Manometer Test Kit	JT05698	Used to check engine crankcase vacuum.
Vacuum Gauge	JT03503	Used to check engine crankcase vacuum.
Lapping Tool	- - -	Valve lapping
Dial Indicator	- - -	Automatic compression relief test, valve inspection, crankshaft end play.
Spark Plug Ground	JDM74A5	Used to prevent accidental engine starting during tests.
90° Elbow Fitting Hose Assembly	JT03338 JT03017	Used to connect pressure gauge to engine when performing engine oil pressure test.
Pressure Gauge Assembly	JT03344	Used to read engine oil pressure when performing engine oil pressure test.
Pressure Gauge	JDG356	Used to check fuel pump performance.
Spark Tester	D-05351ST	Used to check overall condition of ignition system.
Valve Spring Compressor	JDM70	Used to remove and install valve springs.
Current Gun	JT05712	Used to check starter performance.

## Other Materials

### Other Material

Part No.	Part Name	Part Use
TY24416	MPG-2® Multipurpose Grease	Apply to engine crankshaft
	SCOTCH-BRITE® Abrasive Sheets/ Pads	Clean cylinder head
	Valve Guide Cleaner	Clean valve guides
	Prussian Blue Compound	Check valve seat contact
TY24416	Lithium Base Grease	Pack oil seals
	Zinc Oxide/Wood Alcohol	Check block for cracks
	Mineral Spirits	Clean armature
	Valve Lap Compound	Lap valves
PM37418 LOCTITE 242	Thread Lock and Sealer (Medium Strength)	Apply to threads of throttle and choke plate screws
PM37397 LOCTITE 592	Thread Sealant (General Purpose) with TEFLON,	Apply to threads of pipe plugs

MPG-2 is a registered trademark of DuBois USA.

LOCTITE is a registered trademark of the Loctite Corp.

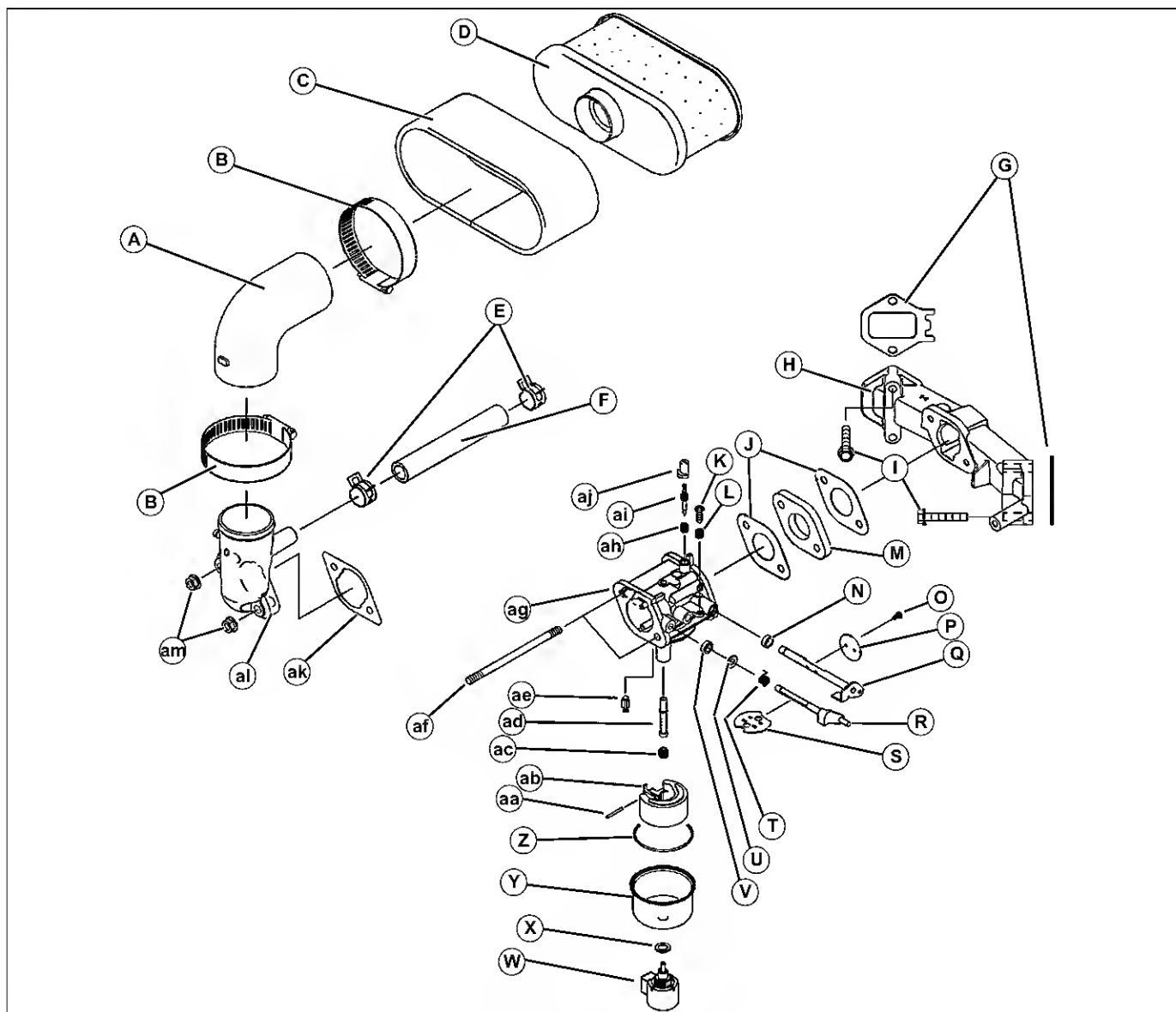
SCOTCH-BRITE is a registered trademark of the 3M Co.

TEFLON® is a registered trademark of DuPont.

# ENGINE - KAWASAKI (FS541V) COMPONENT LOCATION

## Component Location

### Intake and Carburetor Components



MX43653

- A- Rubber Elbow
- B- Hose clamp
- C- Foam Pre-Cleaner
- D- Air Filter
- E- Clamps
- F- Breather Hose
- G- Intake Manifold Gaskets
- H- Intake Manifold
- I- Bolts
- J- Gasket
- K- Idle Speed Screw

- L- Spring
- M- Insulator
- N- Seal
- O- Screw (2)
- P- Throttle Valve
- Q- Throttle Shaft
- R- Choke Shaft
- S- Choke Valve
- T- Spring
- U- Washer
- V- Seal
- W- Fuel Shutoff Solenoid

## ENGINE - KAWASAKI (FS541V) COMPONENT LOCATION

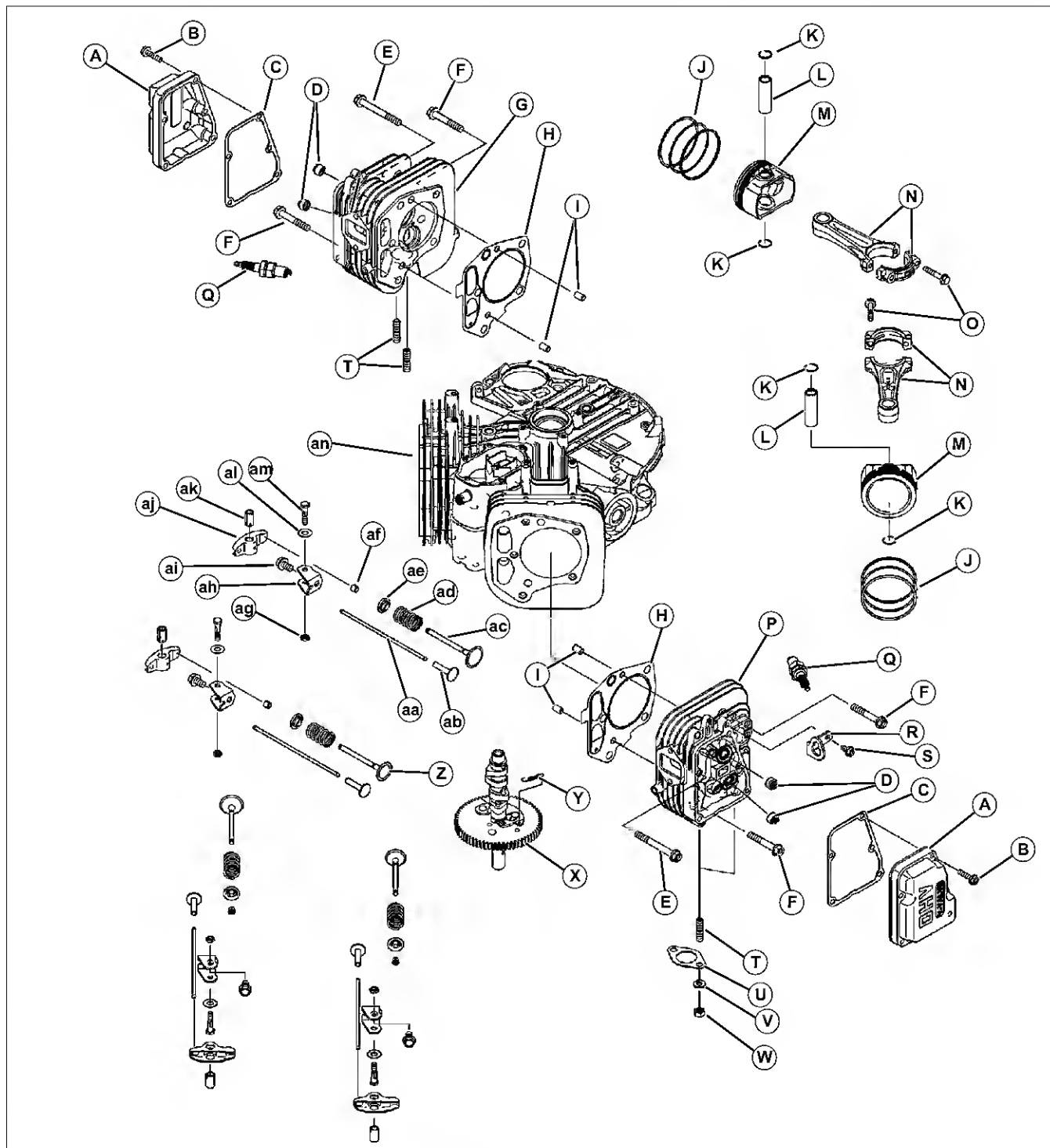
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X- Gasket  
Y- Float Bowl  
Z- Gasket  
AA- Float Pin  
AB- Float  
AC- Main Jet  
AD- Nozzle  
AE- Float Valve  
AF- Stud  
AG- Carburetor Body  
AH- Spring  
AI- Idle Mixture Screw  
AJ- Limiter Cap  
AK- Gasket  
AL- Elbow  
AM- Nut



# ENGINE - KAWASAKI (FS541V) COMPONENT LOCATION

## Engine Top End



- A- Valve Cover
- B- Cap Screw (10)
- C- Valve Cover Gasket
- D- Valve Stem Oil Seals
- E- Cylinder Head Bolt (long)
- F- Cylinder Head Bolt (short)
- G- Cylinder Head No. 1

- H- Cylinder Head Gasket
- I- Alignment Pins
- J- Piston Rings
- K- Piston Pin Retainer
- L- Piston Pin
- M- Piston
- N- Connecting Rod Assembly

## ENGINE - KAWASAKI (FS541V) COMPONENT LOCATION

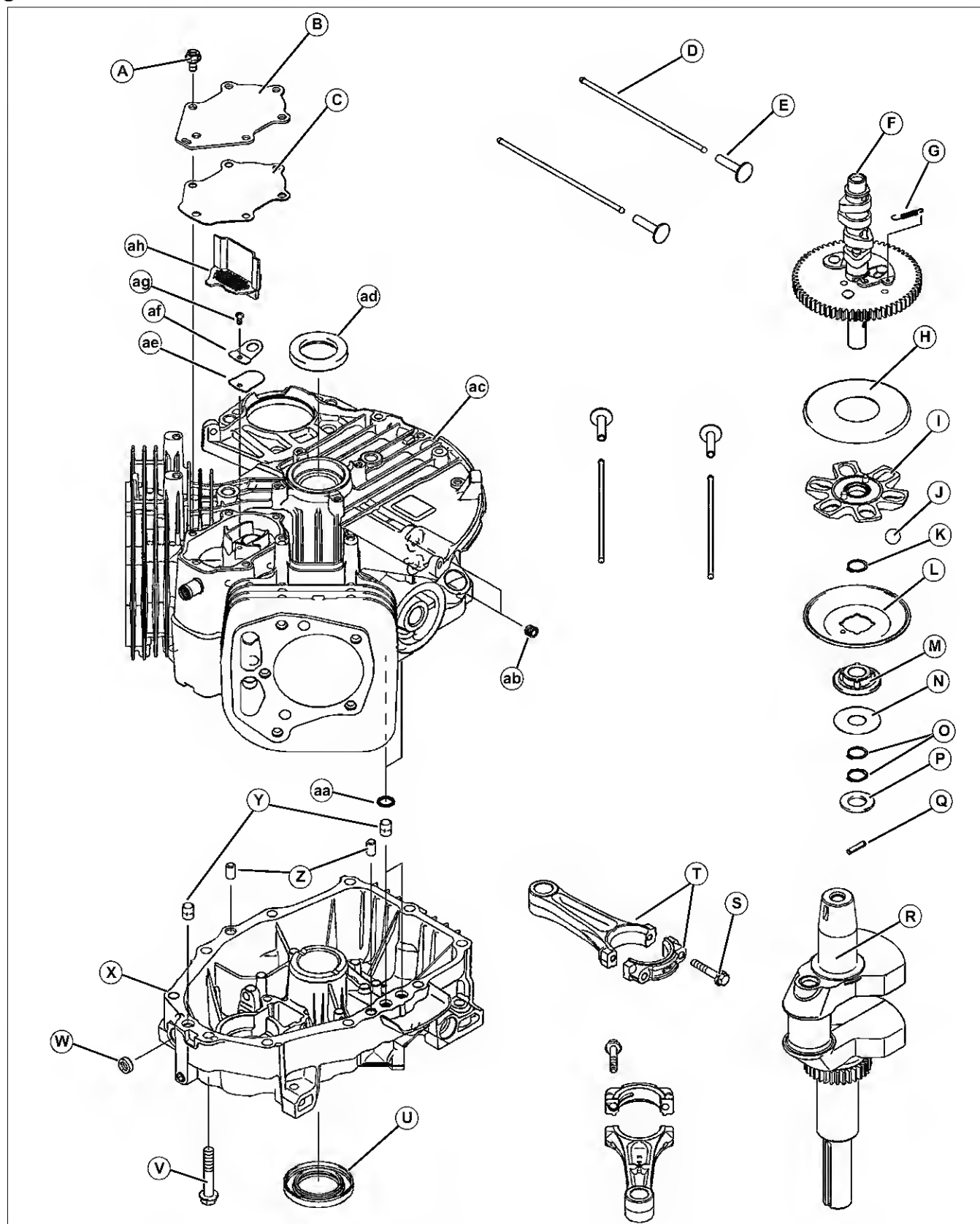
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O- Connecting Rod Cap Screw  
P- Cylinder Head No. 2  
Q- Spark Plug (2)  
R- Engine Lift Eyelet  
S- Bolt  
T- Stud (4)  
U- Gasket (2)  
V- Lockwasher (4)  
W- Nut  
X- Camshaft  
Y- ACR Spring  
Z- Exhaust Valve <sup>1</sup>  
AA- Pushrod  
AB- Tappet  
AC- Intake Valve  
AD- Valve Spring  
AE- Valve Spring Retainer  
AF- Collets (2 for each valve)  
AG- Nut  
AH- Rocker Arm Bracket  
AI- Bolt  
AJ- Rocker Arm  
AK- Eccentric Collar  
AL- Washer  
AM- Valve Clearance Adjusting Bolt

*1. All valve parts Z thru AM are the same for each cylinder.*

# ENGINE - KAWASAKI (FS541V) COMPONENT LOCATION

## Engine Crankcase



MX43654

A- Bolt

B- Breather Cover

C- Breather Gasket

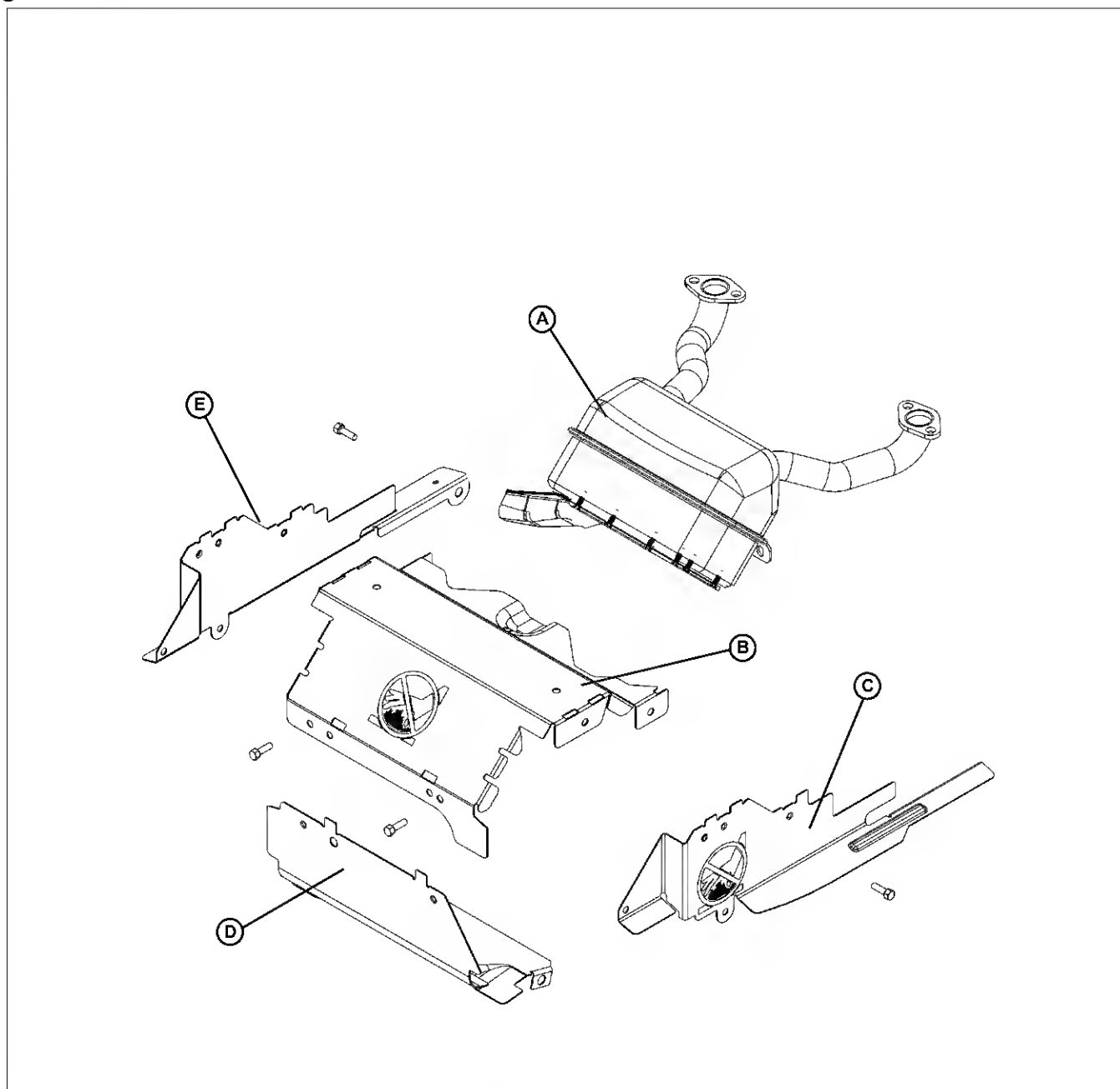
## ENGINE - KAWASAKI (FS541V) COMPONENT LOCATION

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D- Push Rod  
E- Tappet  
F- Camshaft  
G- ACR Spring  
H- Plate  
I- Guide  
J- Ball  
K- Snap Ring  
L- Concave Plate  
M- Sleeve  
N- Washer  
O- Snap Ring  
P- Washer  
Q- Pin  
R- Crankshaft  
S- Connecting Rod Bolt (4)  
T- Connecting Rod Assembly (2)  
U- Oil Seal  
V- Crankcase Cover Bolt  
W- Governor Shaft Seal  
X- Crankcase Cover  
Y- Tube  
Z- Pin  
AA- O-Ring  
AB- Pipe Plug  
AC- Cylinder Block  
AD- Oil Seal  
AE- Breather Valve  
AF- Breather Plate  
AG- Screw  
AH- Breather

# ENGINE - KAWASAKI (FS541V) COMPONENT LOCATION

## Engine Shields



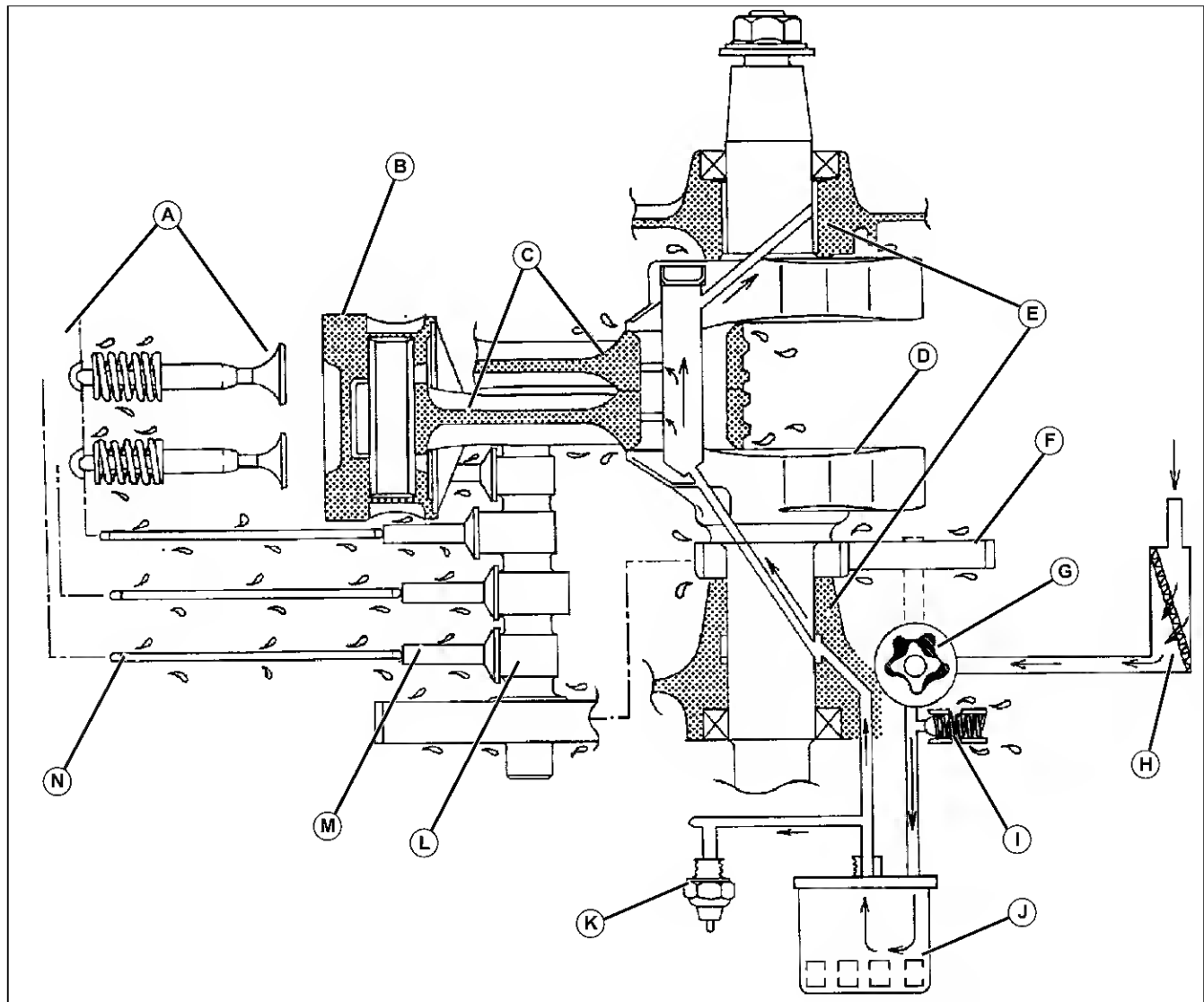
MX43656

- A- Muffler
- B- Upper Shield
- C- Left Shield
- D- Lower Shield
- E- Right Shield

# ENGINE - KAWASAKI (FS541V) THEORY OF OPERATION

## Theory of Operation

## Engine Oil Flow Chart



M99565

### Lubrication System Operation

A- Rocker Arms and Valves

B- Piston

C- Connecting Rods

D- Crankshaft

E- Crankshaft Main Bearings

F- Oil Pump Gear

G- Oil Pump

H- Pick-up Screen

I- Oil Pressure Relief Valve

J- Oil Filter

K- Oil Pressure Sensor (if equipped)

L- Camshaft

M- Tappets

N- Push Rods

#### Function:

To provide pressurized oil to lubricate internal engine components.

#### Theory of Operation:

A positive displacement gerotor pump is used to pressurize the lubrication system. The lubrication system is protected by an oil pressure relief valve, low oil pressure switch (if equipped), and an oil filter with bypass valve.

The oil pump draws oil from the sump through the pick-up screen. Pressure oil from the pump flows through the pump outlet passage past the oil pressure relief valve. The oil pressure relief valve limits the oil pressure to approximately **294 - 686 kPa (43 - 99 psi)** and protects the oil pump from damage if an oil passage becomes blocked. If the oil pressure exceeds 296 kPa (43 psi), the relief valve opens

# ENGINE - KAWASAKI (FS541V) THEORY OF OPERATION

allowing oil to return to the sump. The relief valve is not adjustable.

Pressure oil flows past the relief valve to the oil filter. The filter contains a bypass valve which opens at **78.5 - 117.5 kPa (11.4 - 17.1 psi)** if the element becomes plugged to ensure engine lubrication.

Filtered pressure oil flows through a passage in the oil sump to the crankshaft main bearing (PTO side). Drilled passages in the crankshaft distribute oil from the main bearings to the connecting rod journals and crankshaft main bearings (flywheel side). A drilled passage in the connecting rods allows oil from the connecting rod journal to lubricate the piston and cylinder walls.

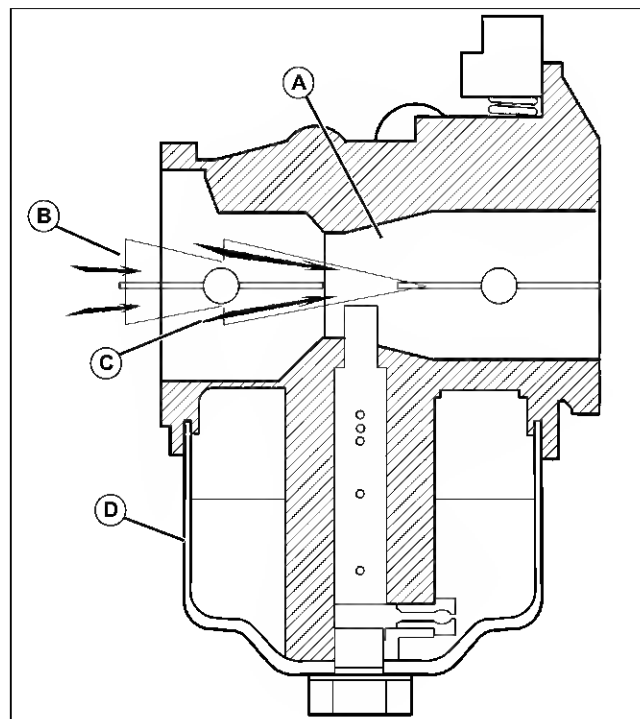
In the cylinder head, the rocker arms, valves, and pushrods are lubricated by an oil/air mixture carried through an upper lubrication passage from the breather chamber. As this oil/air mixture is swirled around the rocker arm chamber, the oil particles cling to the moving parts, lubricating them. Eventually these oil particles collect into a liquid state again in the lower portion of the rocker arm chamber. A small return passage is provided to return this liquid state oil back into the crankcase.

The breather creates a negative pressure in the crankcase which prevents oil from being forced out of the engine through the piston rings, oil seals or gaskets. Cylinder blow-by gases go through the crankcase to the breather chamber. They are drawn into the engine side of the air cleaner through the cylinder head and mixed with the clean air flow as part of the emission control system.

The camshaft gear, camshaft, tappets, coolant pump gear, governor gear, oil pump gear, and crankshaft gear are lubricated by oil splash generated by the internal moving parts during operation.

## Carburetor Operation

### Function



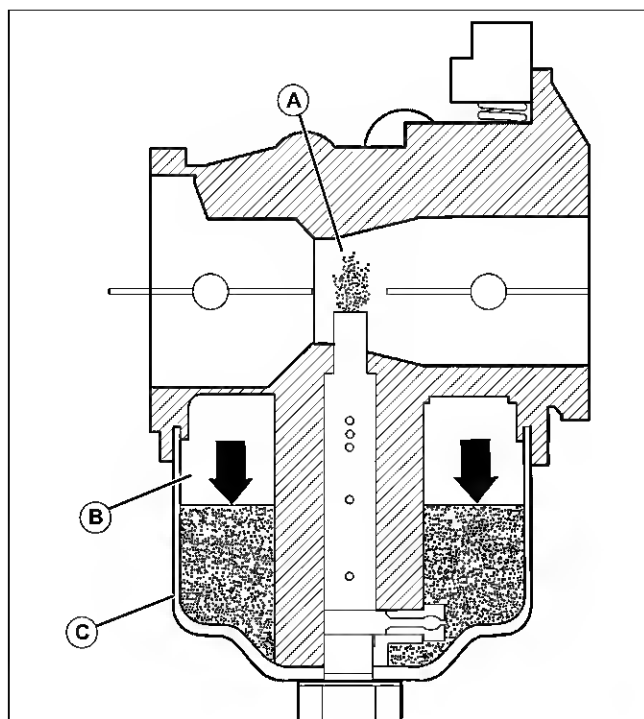
- A- Venturi
- B- Carburetor Throat
- C- Increased Air Speed
- D- Fuel Bowl

The function of the carburetor is to create fuel flow, atomize the fuel, and meter the air/fuel mixture so it can be combusted in the engine. To create fuel flow through the carburetor, there must be a pressure differential between the fuel bowl and the throat of the carburetor.

### Venturi

Air goes through the carburetor throat. When it reaches the venturi, the air speed is increased and the air pressure is decreased. The venturi is a restriction in the carburetor located between the choke and throttle valves. The restriction causes air to speed up resulting in a lower than atmospheric pressure area in the carburetor throat.

# ENGINE - KAWASAKI (FS541V) THEORY OF OPERATION



- A- Venturi Low Pressure
- B- High Pressure
- C- Fuel Bowl

A vent passage in the carburetor maintains pressure from the atmosphere on the fuel in the fuel bowl. Since fluids flow from areas of higher pressure to areas of lower pressure the resulting pressure differential between the fuel bowl (high pressure) and the venturi (low pressure), causes fuel to be pushed (flow) from the fuel bowl to the venturi.

There are two types of bowl venting: external and internal.

**Note: Late model carburetors are internally vented to meet emissions standards.**

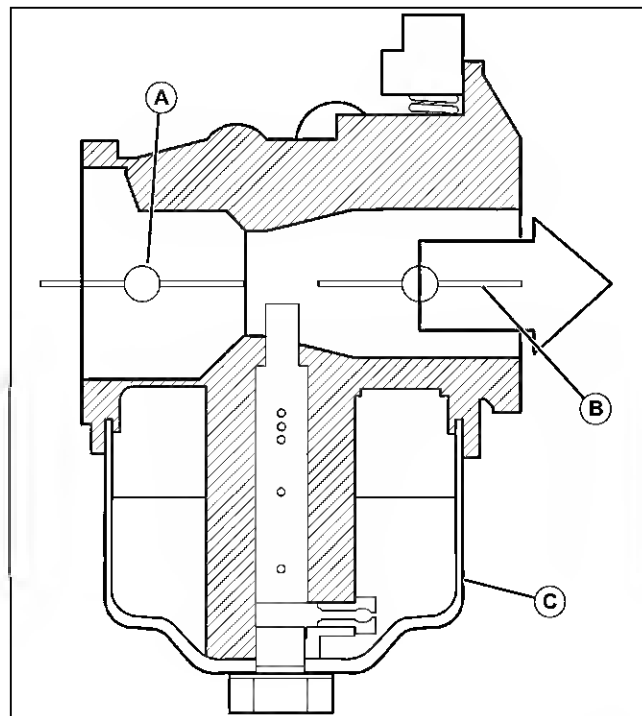
Externally vented carburetors exert direct atmospheric pressure from outside of the air filter onto the fuel in the bowl.

Internally vented carburetors exert indirect atmospheric pressure from inside the air filter, ahead of the choke valve, onto the fuel in the bowl.

## Fuel Bowl and Float

The fuel bowl is the fuel reservoir for the carburetor. In order to maintain the proper fuel air/mixture, the fuel level must be constant. The float maintains the level of fuel in the bowl while regulating the fuel flow to match the demands of the engine by controlling the inlet float valve (needle).

## Control Valves



- A- Choke Valve
- B- Throttle Valve
- C- Fuel Bowl

The carburetor has two control valves: throttle valve and choke valve.

The throttle valve is operated by the throttle lever and controlled by the governor. The throttle valve controls how much air and fuel enters the cylinder(s).

The choke valve, located before the venturi, creates a restriction when closed. The function of the choke valve is to increase the pressure differential between the fuel bowl and the venturi area. This results in increased fuel flow from the bowl to the venturi, enriching the air/fuel mixture.

In some engines, a primer is used in place of a choke valve to push fuel into the venturi.

## Concept of Idle

Governed engines are designed to maintain a specific engine speed.

Governed engines with no load (PTO disengaged, drive in neutral) are said to be at "idle" regardless of engine speed. When the operator selects the low speed position with no load, the engine is at low idle. When the operator selects the high speed position with no load, the engine is at high idle.

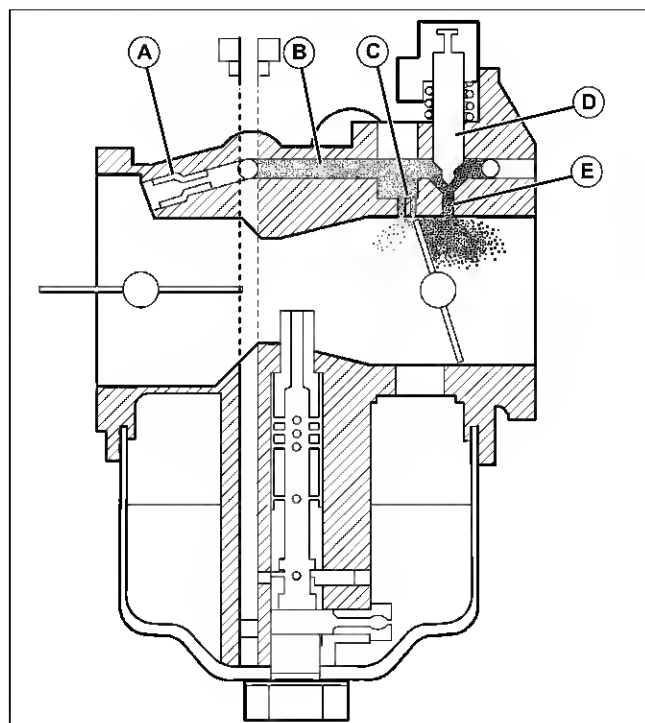
Carbureted engines account for these situations with two circuits; an idle circuit (no load) and a main circuit (under



# ENGINE - KAWASAKI (FS541V) THEORY OF OPERATION

load).

## Idle Circuit



MX47329

- A- Air Bleed
- B- Idle Circuit
- C- Transitional Bypass Openings
- D- Pilot Valve
- E- Pilot Opening

The idle circuit, on a governed engine, delivers air and fuel primarily when the engine is not under load (PTO disengaged, drives in neutral).

Fuel flow enters the idle circuit from the main jet but is metered by the idle jet. The fuel is then emulsified with air passing through an air bleed and combining with the fuel. The air/fuel mixture travels to the transitional bypass openings and the pilot opening.

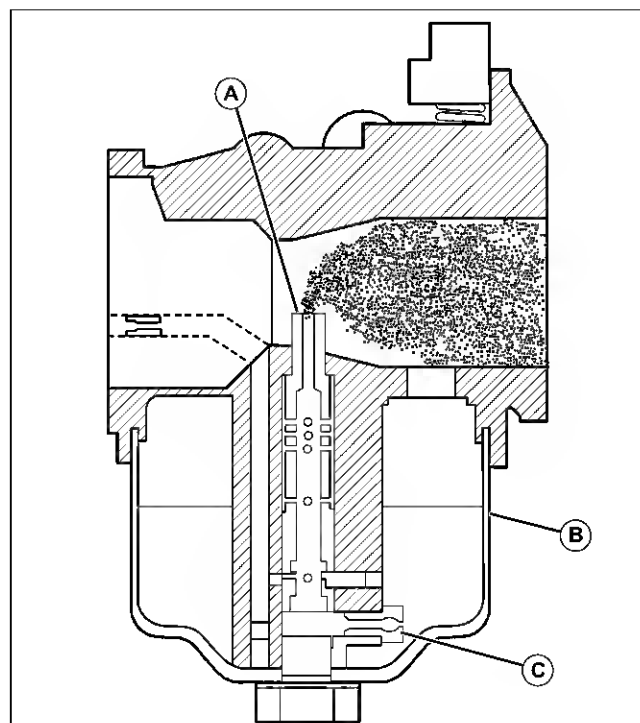
When the throttle valve is closed, the engine receives its air/fuel mixture through the pilot opening. The pilot opening is used for low idle operation. The pilot opening is located between the closed throttle plate and the intake manifold. The opening has a pilot screw that allows for some adjustment. This adjustment primarily affects low idle.

When the governor slightly opens the throttle valve for high idle or when a load is applied, the transitional bypass openings are exposed. These additional openings increase air/fuel flow to the engine.

Once the engine is under a heavier load, the throttle valve is opened beyond the transitional bypass openings. At this point the carburetor receives fuel primarily from the main

circuit.

## Main Circuit



MX47330

- A- Emulsion Tube
- B- Fuel Bowl
- C- Main Jet

The main circuit, on a governed engine, is used only when the engine is under load. Fuel flows from the fuel bowl through the fixed main jet into the main circuit.

Air enters through a metered orifice (air-bleed) and emulsifies (mixes) air and fuel as it travels up the emulsion tube to the venturi.

Emulsification is an important process to properly atomize the fuel and promote efficient combustion.

## Fuel Shutoff Solenoid

The fuel shut-off solenoid reduces fuel flow to the main circuit. The function of the fuel shut-off solenoid is to minimize after-bang.

At engine start up, the fuel shut-off solenoid is energized and the poppet retracts from the seat in the bowl, allowing fuel to enter into the main jets.

To bench test the fuel shut-off solenoid, apply light pressure to the tip to simulate its mounting in the fuel bowl and apply 12 volts DC. If the needle retracts, the solenoid is working. Verify the tip is secured to the plunger.

# ENGINE - KAWASAKI (FS541V) DIAGNOSTICS

## Diagnostics

### Engine Troubleshooting Guide



**Caution: Avoid Injury!** The engine may start to rotate at any time. Keep hands away from moving parts when testing.

**Note:** To test specific electrical components, see *Electrical Section* and refer to either *Diagnostics or Tests & Adjustments* for further guidance.

Test Conditions:

- Operator on seat.
- PTO switch in off position.
- Brake on.

### Engine Diagnostics

#### Engine Doesn't Crank

1. Are battery cables loose or dirty?

Yes: Clean and tighten cables and connections.

No: Go to next step.

2. Is battery fully charged? See "Battery Test" in the Electrical section.

Yes: Go to next step.

No: Charge battery. See "Charge Battery" in the Electrical section.

3. Is key switch working correctly?

Yes: Go to next step.

No: Test switch. See "Key Switch Test" in the Electrical section. Replace as needed.

4. Is starter motor defective? See "Starting Motor Troubleshooting Guide" on page 172.

Yes: Repair or replace.

No: Go to next step.

5. Is stator defective? See "Stator Output Test" in the Electrical section.

Yes: Repair or replace.

No: Go to next step.

6. Has engine seized?

Yes: See engine repair section.

No: Go to next step.

7. Is starting motor or solenoid defective?

Yes: Repair or replace. See "Starting Solenoid Test"

and "Starting Motor Amperage Draw Test - Loaded" in the Electrical section.

No: Go to next step.

8. Is there an open circuit in wiring?

Yes: Repair or replace.

No: Go to next step.

9. Is the fuel shutoff solenoid operating correctly?

Yes: Go to next step.

No: Repair or replace.

10. Is the fuel filter or fuel lines clogged?

Yes: Clean or replace as necessary.

No: Go to next step.

11. Is the fuel pump operating correctly? See "Fuel Pump Test" on page 187.

Yes: Go to next step.

No: Clean or replace as necessary.

12. Is there water in the fuel?

Yes: Drain and replace fuel.

No: Go to next step.

13. Are the valves adjusted properly?

Yes: Go to next step.

No: Adjust valve clearance. See "Valve Clearance Adjustment" on page 182.

14. Does engine have correct compression? See "Cylinder Compression Pressure Test" on page 182.

Yes: Go to next step.

No: Check for seized or burned valves, broken piston rings, or worn cylinders.

15. Is air sucked through carburetor or intake manifold flanges?

Yes: Tighten manifold flange nuts or replace damaged gasket(s).

No: Go to next step.

#### Engine Hard To Start

1. Are battery cables loose or dirty?

Yes: Clean and tighten cables and connections.

No: Go to next step.

2. Is there a strong blue spark? See "Spark Test" on page 187.

Yes: Go to next step.

No: Adjust or replace ignition coil(s). See "Ignition Coil Air Gap Adjustment" on page 188.

# ENGINE - KAWASAKI (FS541V) DIAGNOSTICS

3. Are sparks produced between high tension lead and ignition block. Check high tension leads, and ignition coil air gap.

Yes: Repair or replace parts as needed.

No: Go to next step.

4. Is engine compression good? See "Cylinder Compression Pressure Test" on page 182.

Yes: Go to next step.

No: Check piston rings and cylinder for wear. . Inspect cylinder head.



**Caution: Avoid Injury! Keep spark plug as far away from the plug hole as possible. Gasoline spray from the open cylinders may be ignited by ignition spark and cause an explosion or fire.**

5. Make starting attempts a number of times, remove spark plug and observe electrodes. After starting attempts, are spark plug electrodes wet?

Yes: Check for excessive use of choke, plugged air cleaner, or float bowl level too high.

No: Go to next step.

## Engine Runs Erratically

1. Is fuel delivery correct? See "Fuel Pump Test" on page 187.

Yes: Go to next step.

No: Check for defective fuel pump or plugged fuel lines or fuel tank.

2. Is fuel present in carburetor?

Yes: Go to next step.

No: Check for plugged air/fuel passages in carburetor. See "Carburetor Removal, Disassembly, and Installation" on page 191.

3. Is there contamination in fuel lines or fuel tank?

Yes: Repair or replace parts as needed.

No: Go to next step.

## Engine Malfunctions At Low Speed

1. Is unusual smoke emitted out of muffler?

Yes: Check choke. See "Choke Cable Adjustment" on page 179.

No: Go to next step.

2. Does engine rpm drop or engine stall at a certain point when throttle is gradually opened by hand?

Yes: Check for obstruction or plugged passage in carburetor. See "Carburetor Removal, Disassembly,

and Installation" on page 191.

No: Go to next step.

3. Is air sucked through carburetor or intake manifold flanges?

Yes: Tighten manifold flange nuts or replace damaged gasket(s).

No: Go to next step.

4. Are valve clearances set correctly? See "Valve Clearance Adjustment" on page 182.

Yes: Go to next step.

No: Adjust valves.

## Oil Consumption Is Excessive

1. Check for oil leaks, high oil level, clogged breather valve, or plugged drain back hole in breather. Is oil viscosity correct?

Yes: Repair as required.

No: Replace oil with correct viscosity. Go to next step.

2. Is compression correct? See "Cylinder Compression Pressure Test" on page 182.

Yes: Go to next step.

No: Check for worn, stuck, or broken piston rings, or worn cylinder bore.

## Low Oil Pressure

1. Is oil level correct?

Yes: Go to next step.

No: Top off oil to correct level.

2. Is oil filter clogged?

Yes: Replace oil filter.

No: Go to next step.

3. Is oil of correct viscosity?

Yes: Go to next step.

No: Change engine oil with correct viscosity.

4. Check for oil leaks, high oil level, clogged breather valve, or plugged drain back hole in breather. Is oil viscosity correct?

Yes: Repair as required.

No: Go to next step.

5. Is oil relief valve worn?

Yes: Clean, adjust or replace relief valve.

No: Go to next step.

6. Is oil pump operating correctly? See "Engine Oil Pressure Test" on page 186.

Yes: Go to next step.

# ENGINE - KAWASAKI (FS541V) DIAGNOSTICS

No: Replace oil pump.

7. Is there fuel in the oil?

Yes: Check for broken or seized piston rings or worn cylinder(s).

No: Go to next step.

8. Is oil pump screen clogged or pick up tube cracked?

Yes: Clean screen and repair or replace pick up tube.

No: Go to next step.

9. Is there excessive crankshaft or rod bearing clearance?

Yes: Regrind crank and replace bearings.

No: Go to next step.

10. Intake/exhaust valves or guides worn?

Yes: Replace valves and head(s).

No: Go to next step.

## Contamination in Crankcase

1. Is there fuel in the crankcase?

Yes: Check for broken or seized piston rings or worn cylinder(s). Check for worn or seized exhaust valves.

No: Go to next step.

2. Is there water in the crankcase?

Yes: Check to make sure that crankcase breather is working correctly. See "Crankcase Vacuum Test" on page 185, and "Breather Inspection" on page 196

## Starting Motor Troubleshooting Guide



**Caution: Avoid Injury! The engine may start to rotate at any time. Keep hands away from moving parts when testing.**

**Important: Avoid Damage! If starting motor does not stop rotating by turning ignition switch to Off position, disconnect negative (-) lead from battery as soon as possible.**

**Note: To test specific electrical components, see Electrical section and refer to either Diagnostics or Tests and Adjustments for further guidance.**

## Starting Motor Diagnostics

### Starter Does Not Rotate

1. Is there a clicking sound from the starter solenoid?

Yes: Go to next step.

No: Test starting solenoid. See "Starting Solenoid Test"

in the Electrical section.

2. Check that all starting conditions are met?

Yes: Go to next step.

No: Make sure all starting conditions are met.

3. Are battery cables loose or dirty?

Yes: Clean and tighten cables and connections.

No: Go to next step.

4. Is battery fully charged? See "Battery Test" in the Electrical section.

Yes: Go to next step.

No: Charge battery. See "Charge Battery" in the Electrical section.

5. Is key switch working correctly?

Yes: Go to next step.

No: Repair or replace key switch. See "Key Switch Test" in the Electrical section.

6. Is engine seized?

Yes: See engine repair section.

No: Go to next step.

### Starter Rotates Slowly

1. Are battery cables loose or dirty?

Yes: Clean and tighten connections and cables.

No: Go to next step.

2. Is battery fully charged? See "Battery Test" in the Electrical section.

Yes: Go to next step.

No: Charge battery. See "Charge Battery" in the Electrical section.

3. Is there a clicking sound from the starter solenoid?

Yes: Go to next step.

No: Test starter solenoid. See "Starting Solenoid Test" in the Electrical section.

4. Is engine seized?

Yes: See engine repair section.

No: Go to next step.

5. Is starting motor or solenoid defective?

Yes: Repair or replace. See related tests in the Electrical section.

# ENGINE - KAWASAKI (FS541V) DIAGNOSTICS

## Carburetor Troubleshooting Guide

### Engine Will Not Start

1. Is there fuel?

Yes: Go to next step.

No: Add fuel, check fuel lines.

2. Is fuel line plugged?

Yes: Clean fuel line and fuel filter. Check for fuel supply at carburetor.

No: Go to next step.

3. Does the fuel solenoid open?

Yes: Go to next step.

No: Test solenoid and power to solenoid. See Electrical section.

4. Is the main jet clogged?

Yes: Disassemble and clean jet and passages.

No: Go to next step.

5. Is the needle valve stuck closed?

Yes: Check for old or gummy fuel. Clean carburetor. Check valve tip.

No: Go to next step.

### Engine Cranks But Is Hard to Start

1. Is the air filter clean?

Yes: Go to next step.

No: Clean or replace air filter.

2. Is the choke plate opening properly?

Yes: Go to next step.

No: Adjust choke cable. See choke cable and throttle cable adjustment.

3. Check passages in carburetor. Are passages open and free of debris or varnish?

No: Clean carburetor.

### Engine Idles But Does Not Run Under Load

1. Check main jet. Is main jet dirty?

Yes: Clean carburetor.

No: Go to next step.

2. Check main jet for proper size. Is correct main jet used?

No: Replace main jet.

### Engine Idles, Runs (loaded or not) Then Stops

1. Is the fuel system properly vented?

Yes: Go to next step.

No: Check fuel cap if vented cap is used. Check vent lines to carburetor for kinks, or collapsed or weak areas.

2. Is dirt in the bowl being sucked into main jet?

Yes: Check float bowl for dirt or corrosion, clean bowl. Check main jet for loose debris.

### Engine Does Not Idle Properly (hunts or surges)

1. Check to see if the problem is governor or carburetor: Hold the throttle plate closed to force engine to idle. Does the engine continue to run? check governor. If the engine stalls - suspect idle circuit.

Yes: Check governor for proper operation.

No: If engine stalls, check idle circuit. Clean carburetor with attention to idle circuit passages.

### Engine Idles, Does Not Run Properly At Wide Open Throttle (WOT)

1. Check float bowl for dirt or corrosion. Check for dirt between needle valve and seat. Is dirt or debris present?

Yes: Clean bowl and valve seat.

No: Go to next step.

2. Is float sticking or not set properly?

Yes: Clean float pivot. Adjust float.

No: Go to next step.

3. Check air passage and pilot jet for debris or varnish. Is there debris in the idle air bleed or pilot jet?

Yes: Clean carburetor.

## Carburetor Air/Fuel Diagnosis

Defects in carburetors would be apparent very early in the life of the engine. The majority of fuel system problems are related to stale or improper fuel or dirt. This section is to help you diagnose fuel system problems.

### Initial Checklist

- How old is the fuel?
- Does the fuel have a foul smell?
- Is the fuel cloudy, dark or dirty?
- Is the fuel tank cap air vent clean and open?
- Is a clean, correct air filter installed?
- Has the ignition system been verified?
- Is the air filter and carburetor attached properly?
- Is the intake manifold loose and/or leaking?

# ENGINE - KAWASAKI (FS541V) DIAGNOSTICS

- Is the fuel shut-off solenoid operating properly?
- Is the governor throttle linkage moving properly?
- Is the float operating properly?
- If the carburetor is externally vented, is the vent line unrestricted?

**Note:** *Other engine failures such as plugged exhaust or improper valve clearance can cause symptoms similar to faulty fuel supply. Verify the quality of the engines mechanical and electrical systems.*

## Engine Surge

An engine that surges may have an improper air/fuel mixture or a misadjusted or worn governor.

Attempt to manually control the throttle at low and high idle to determine which system is causing the surge. If the engine speed can be held constant check the governor system. If the engine surge cannot be controlled manually, check the fuel system.

Fuel system issues may consist of:

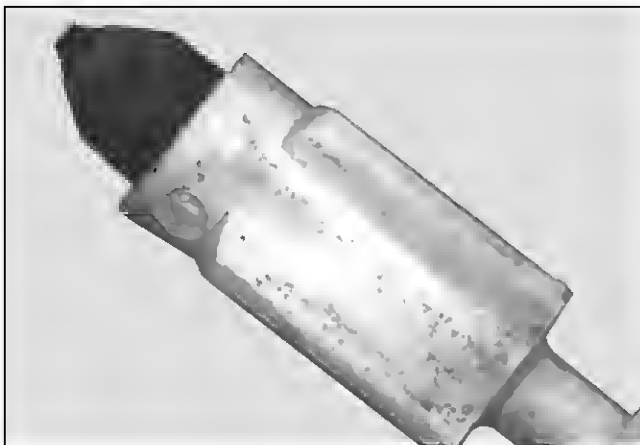
- Improper air/fuel mixture caused by air leaks around the throttle shaft, intake and/or insulator gaskets.
- Minor restrictions inside the carburetor passages from varnish and debris buildup in the idle circuit. Properly cleaning the carburetor will likely fix the problem.

## Rich Air/Fuel Mixture

There are several possible causes of a rich running condition such as: improper or stale fuel, short-tripping, air filter, choke adjustment and/or vent tube location.

**Note:** *Verify the ignition system. A rich running condition can have the same symptoms as an improperly operating ignition system.*

## Float Valve



MX47331

**Float Valve with Worn Tip Shown**

Fuel level in the float bowl is regulated by the float and the float valve. A worn float valve tip provides too much fuel and will cause a rich condition.

## Improper or Stale Fuel

Poor fuel quality can cause an engine to appear to be running rich. Improper or stale fuel can cause engine components to stick or deteriorate.

## Short-Tripping

A common misdiagnosis comes from short-tripping machines (engines that are started for short periods of time). Short-tripping causes the engine to develop black, sooty spark plugs and contamination in the oil. Over time, short-tripping can lead to glazed cylinder walls. To prevent this, every time the engine is started, allow the engine to reach operating temperature and load the machine.

## Air Filters

**Note:** *Late model carburetors are internally vented to meet emissions standards.*

Engines with externally vented carburetors with a dirty air filter will exhibit rich running conditions. When a dirty air filter restricts air flow to the carburetor, the low pressure in the venturi drops even further, resulting in a higher pressure differential between the fuel bowl and the venturi. Therefore, a dirty air filter can enrich the air/fuel mixture to the point that performance will drop.

Engines with internally vented carburetors will not exhibit rich running conditions with a dirty air filter. When a dirty air filter restricts air flow to the throat of the carburetor, an equal reduction will be applied to the bowl vent. Internally vented carburetors maintain the pressure differential between the bowl and the venturi resulting in a consistent air/fuel mixture over the life of the air filter.

## Vent Tube Location

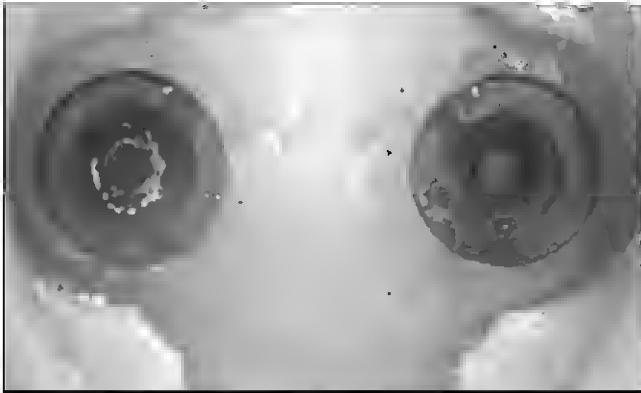
With an externally vented carburetor, a rich or lean run condition could also be caused by the location of the float bowl vent tube. The purpose of the vent tube is to allow atmospheric pressure into and out of the float bowl. Air from the cooling fan at the vent tube opening can cause a pressure increase or decrease on the fuel in the float bowl and cause the engine to run rich or lean. Check for bulletins and relocate the float bowl vent tube to a location away from any source of turbulence.

# ENGINE - KAWASAKI (FS541V) DIAGNOSTICS

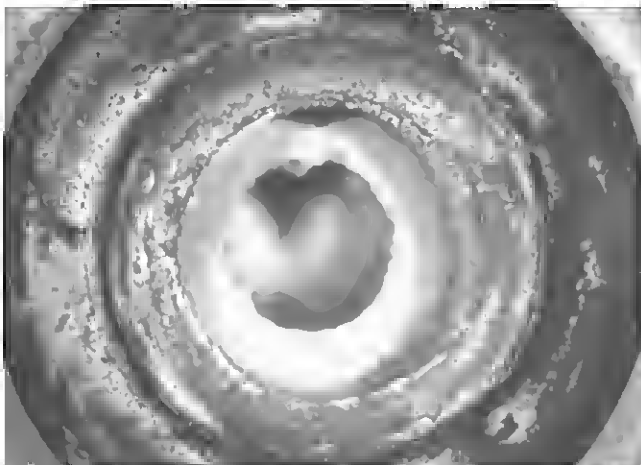
## Carburetor Diagnostic Inspection

Inspect the carburetor float bowl and passages for debris, varnish buildup, and corrosion.

Check for damaged parts or parts installed incorrectly.



MX47332 and MX47333



MX47469

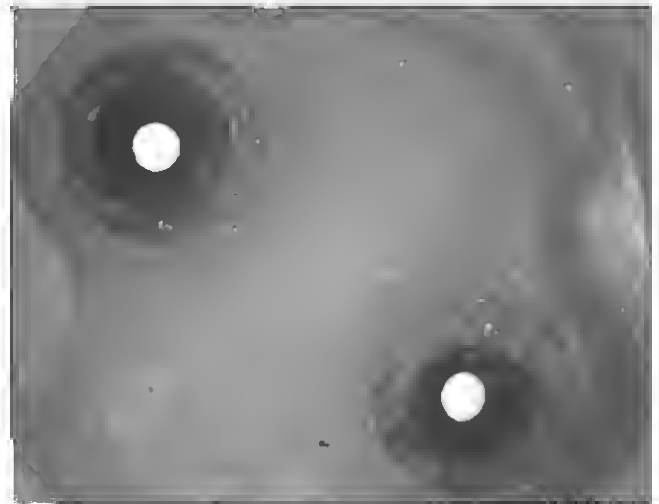
1. White corrosion or green corrosion is usually caused by water. Water can combine with other chemicals and create acids and salts which accelerate corrosion. Water can be absorbed by ethanol, so the more ethanol, the worse the problem.

Extreme corrosion may involve salt water. Sometimes the exterior of the carburetor will also be corroded. The location of the machine (such as coastal regions) will provide additional clues to the cause of corrosion.



MX47472

2. Red or brown corrosion is usually caused by an iron or steel part that has corroded. Look at steel fuel inlet fittings, steel parts in fuel filters. It could also indicate some other contaminant in the fuel. Some microbial contaminations can be reddish.



MX47471

3. Brown varnish and gum deposits are generally from old degraded fuel. It usually has a distinctive "old varnish" smell. Look for it in areas that would be adversely affected, such as fuel and air passages, needles and seats.

4. Damage from excessive ethanol, methanol, MTBE, ethers, will usually be seen as damage to rubber parts. Look for cracks, swelling, shrinking, loss of elasticity, takes a permanent set or becomes hard or brittle. Look for plastic damaged parts.

5. Debris stuck in small orifices and other critical areas. Look in jets, fuel and air passages, fuel inlet needle and seat, idle mixture adjustment needles and seats, idle progression holes, fuel shutoff solenoid plunger, etc. The

# ENGINE - KAWASAKI (FS541V) GENERAL INFORMATION

material of the debris can help determine the source. Look for the following:

- a. Cellulose and other organic fibers are usually grass debris that was ingested by the engine air intake or fuel system, they could also be fibers from the fuel filter element.
  - b. Sand can come from ingesting dirt by the engine air intake system or fuel system or from unclean manufacturing and parts packaging.
  - c. Metallic particles such as aluminum, brass, and iron chips typically come from the manufacturing process and unclean parts packaging and assembly areas.
  - d. Plastic particles usually come from manufacturing processes such as plastic molding, welding, adhesive (epoxy used in fuel filters), and unclean part packaging and assembly areas.
  - e. Rubber particles usually come from the fuel lines, fuel pump diaphragms, or internal parts, and unclean part packaging and assembly areas.
  - f. Cardboard particles and fibers usually come from parts packaging and unclean assembly areas.
  - g. Hair fibers usually come from unclean parts packaging and assembly areas.
6. Wrong parts, such as wrong size jet or left and right jets switched.
7. Damaged parts, such as jets having tool marks that affect the fuel flow, cracked plastic parts, etc.
8. Defective parts such as porosity in castings, excessive flash on castings or molded parts, defective welds or adhesive joints, throttle shafts that fit too tight or too loose, throttle plates out of alignment or not matched to bores, etc. Defective machining is difficult to diagnose unless it's obvious.

## General Information

### Cleaning Carburetors

Debris, corrosion, rust, or varnish can build up in the internal air/fuel passages. Many times the contamination is located in an area of the carburetor that is not visible. In most cases proper cleaning can resolve these issues.

Carburetors and carburetor components can be cleaned by using one of several types of commercial cleaning methods: aerosol sprays, caustic dip tanks, and ultrasonic cleaners.

**Note: Some cleaning chemicals may be flammable and have toxic fumes. Always follow the chemical manufacturer's recommendations. Always wear personal protection gear such as safety glasses**

**protective gloves and work in a well ventilated area. Do not use drill or hard wire to clean carburetor passage ways.**

### Cleaning Procedure

Always follow the solvent manufacturer's recommendations for material compatibility because some solvents may attack metal, plastic or rubber components.

1. Clean debris off the outside of the carburetor before disassembly.
2. Completely disassemble the carburetor per the instructions in the Technical Manual and visually inspect.
3. Determine if carburetor is repairable, excessive corrosion may determine this is not practical.
4. If repairable, clean any remaining dirt and old gaskets from the carburetor.

The preferred method of cleaning is to use an ultrasonic cleaner.

**Important: Avoid Damage!** Wires and metal instruments should not be used. Light damage or deposits on the surface of the float valve seat can be removed using a cotton swab with a mild abrasive such as toothpaste or 800 grit lapping compound.

### Carburetor Assembly

When the carburetor is ready for assembly, lay out all the necessary components on a clean surface. Be aware that even clean shop rags may contain dirt and metal shavings. Assemble the carburetor in accordance with the instructions in the Technical Manual. Keep the following in mind:

- Check the throttle shaft for excessive play or movement and any signs of binding.
- Never use oil on the throttle shaft because it attracts dirt which can cause premature wear of the throttle shaft seals.
- If the throttle shaft was removed use new screws and follow the service manual torque specifications.
- Always check the float and float valve for binding with the float valve installed in its proper position.
- Replacement of all gaskets and seals is necessary when servicing any carburetor.
- Inspect the carburetor insulator for damage and replace if necessary. Be sure to install the insulator using the correct orientation.
- Clean and flush the complete fuel system.
- Fuel lines must be replaced if they are brittle, cracked, excessively soft or damaged.
- Replace the fuel filter and air filter after cleaning the



# ENGINE - KAWASAKI (FS541V) GENERAL INFORMATION

carburetor.

## Cleaning Methods

### Ultrasonic Cleaning Systems

Ultrasonic cleaners use environmentally friendly cleaning solution and sound waves to penetrate deep into carburetor passages. Heating the solution is an option on ultrasonic cleaners that significantly increases the effectiveness of the system. Ultrasonic cleaner systems work by creating sound wave pulses that are transmitted through a cleaning solution. Manufacturers of ultrasonic cleaners claim the pulses create small bubbles that loosen and pulverizes contaminants. Select a chemical solution that is designed specifically for carburetor cleaning.

Generally, chemicals will need to be diluted with water prior to use. When choosing a chemical, consider dilution rates to help determine which chemical is the most cost effective. Consider disposal of cleaning solution before ordering chemicals. Check with local authorities on recommended disposal methods before disposing of any cleaning solution. Ultrasonic cleaners come in many sizes. Most 1.5-2 gallon tanks will be sufficient for carburetors used by John Deere gas engines.

If an Ultrasonic Cleaner is used, place carburetor in and run for 30 minutes at 110 F in the proper solution mix. If the solution is too strong or the carburetor is left in the cleaner for too long, the aluminum body will have a residue on the surface from the aluminum oxidizing.



**Caution: Avoid Injury! Compressed air can cause debris to fly a long distance.**

- Clear work area of bystanders.
- Wear eye protection when using compressed air for cleaning purposes.
- Reduce compressed air pressure to 210 kPa (30 psi).

Rinse the parts in water and dry with compressed air (up to 30 psi).

Wash off and blow ports out in carburetor body/ fuel transfer tubes / and discharge port. Blow compressed air through carburetor passages in the opposite direction of the air/fuel flow (into the smallest passages to flush debris out of the larger passages). This will prevent debris lodging in difficult to clean areas.

### Aerosol Cleaner

Personal safety, environmental concerns and cleaning effectiveness make this method the least desirable. This method can be used on carburetor components that may be damaged by caustic cleaners (rubber seals or other

non-metallic components). When cleaning with aerosol sprays, it is always best to spray in the opposite direction of the air/fuel circuit (into the smallest passages to flush debris out of the larger passages). This will prevent debris lodging in difficult to clean areas.



**Caution: Avoid Injury! Vapors from solvents can be explosive and flammable. Follow the instructions on the container label for safe use of the solvent:**

- Work in a well-ventilated area.
- Wear protective clothing when handling solvent.
- Do not smoke while handling solvents.
- Keep solvent away from flames or sparks.

### Caustic Dip Tanks

Caustic dip tanks use aggressive chemicals to dissolve carbon based contamination. This method is effective for most carburetor cleaning needs.

Rotating the parts in the tank will ensure the cleaning solution flushes out any air pockets left in the passages. Follow the recommendation on the cleaner for submersion times. Disadvantages of the caustic dip tanks are that some carburetor parts may be damaged if left in solution too long.

Personal safety and chemical disposal are additional concerns. Because the chemical is caustic, exposure may cause injury or death. Disposal of used solution can be difficult because most cleaners are considered hazardous waste.

### Fuel

Use only fuels recommended in Operator's Manual:

Use regular grade unleaded fuel with an octane rating of 87 octane or higher. Fuel blends containing up to 10% ethanol or up to 15% MTBE reformulated fuel are acceptable. DO NOT use fuels with more than 10% ethanol (i.e. E85 should not be used because it is 85% ethanol and 15% gasoline) or fuels with more than 15% MTBE reformulated fuel as these products will damage engine and or fuel system. Do not use fuel or additives containing methanol as engine damage can occur.

All fuel today is formulated for the automotive industry. Fuel is "blended" differently for winter and summer use; regardless of where you are. "Winter" fuel is blended for improved vaporization in colder temperatures. Using left over "Winter" fuel in warmer Spring/Summer temperatures will likely cause vapor locking and surging. Newer carburetors on current production machines have less

# ENGINE - KAWASAKI (FS541V) TESTS AND ADJUSTMENTS

tolerance for poor quality fuel because of the tighter specifications required to meet EPA certification.

## Fuel Storage

Since it is difficult to know what type of fuel is in different areas; it is best to handle and maintain fuel as outlined below:

1. Deteriorated/stale fuel causes gum and varnish. This creates deposits on engine valves and in carburetor jets and passages. This is what causes most of the performance problems.
2. Oxygenated (or blended) fuels can deteriorate faster and require more specific storage and usage procedures.
3. The translucent fuel tanks on some model tractors allow a certain amount of sunlight through the tank. This can accelerate the deterioration of the fuel.



**Caution: Avoid Injury! Fuel stabilizer is a hazardous chemical and can be harmful or fatal if swallowed. Do not take internally. Avoid contact with eyes. Avoid breathing the chemical vapors.**

**Read safety instructions on stabilizer container label before using.**

**Fuel stabilizer contains 2,6-di-tert-butylphenol (128-39-2) and aliphatic petroleum distillate (64742-47-8). In case of emergency, contact a physician immediately and call 1-800-424-9300 for material safety information.**

**Note: There is no fuel stabilizer made that will "restore" stale fuel. Fill tanks with fresh, stabilized fuel.**

4. Use fuel from a major name brand supplier. At the same time, add an appropriate amount of Fuel Stabilizer (such as TY25808). Do this when you add fresh fuel to your tank.
5. If engine performance problems arise, try another brand of fuel. You may have to try several different sources.
6. Any fuel over 30 days old is considered "stale".
  - For 2-cycle equipment, purchase as small a quantity of fuel as feasible. If there is doubt about how long the fuel may be stored, add stabilizer right away. JOHN DEERE PREMIUM EXACT MIX 2-Cycle Oil (UP08127) already has a fuel stabilizer added to the oil. When using this oil fuel mix, it will stay fresh for up to 30 days. If storing a 2-cycle powered unit for more than 3 weeks, it is recommended to run the fuel out of the unit.

## Tests and Adjustments

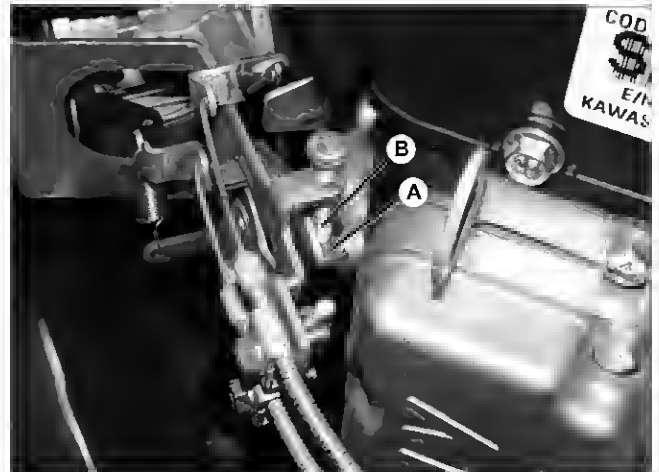
### Throttle Cable Check and Adjustment

#### Reason:

- To make sure the throttle control arm has the proper amount of travel for maximum engine performance.

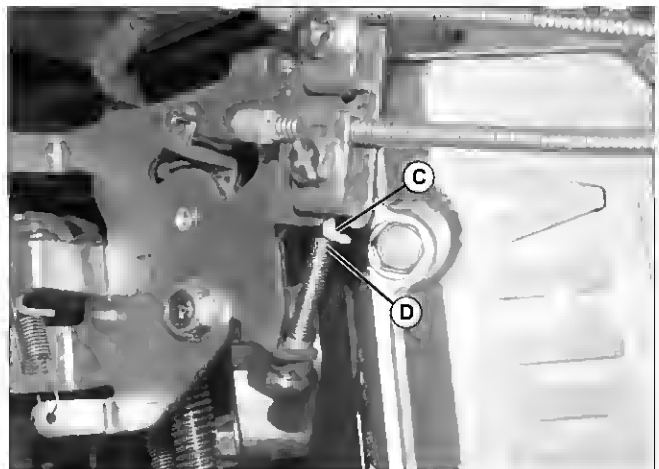
#### Check Procedure:

1. Park machine safely.



MX43643

2. Move throttle lever to SLOW position. Throttle control lever tab (A) should be touching low speed limit screw (B).



MX43644

3. Move throttle lever to FAST position. Throttle control lever tab (C) should be touching high speed limit screw (D).

#### Results:

- If throttle control lever tabs contact limit screws in high and low speed positions, throttle cable adjustment is OK.
- If throttle control lever tabs do not contact limit screws in high either the high or low speed position, perform adjustment procedure below.

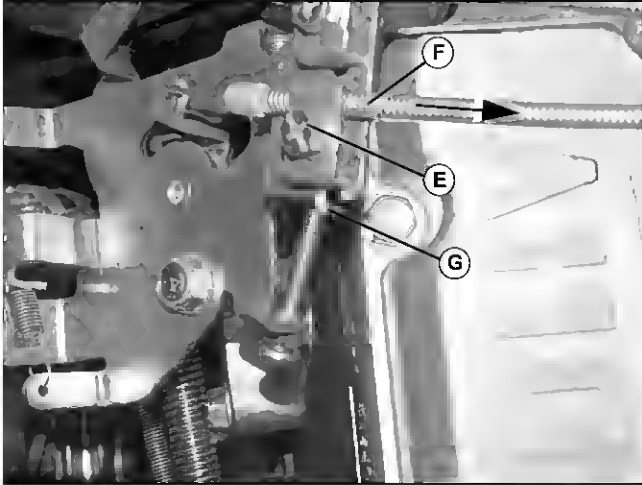
# ENGINE - KAWASAKI (FS541V) TESTS AND ADJUSTMENTS

## Adjustment Procedure:



**Caution: Avoid Injury! Engine components are HOT. Do not touch, exhaust pipe or muffler while making adjustments.**

1. Move throttle lever to FAST position.



2. Loosen cable retainer screw (E).
3. Pull throttle cable (F) in direction shown (arrow) until tab (G) is against high speed limit screw.
4. Make sure throttle control lever on dash is still in FAST position. Tighten retaining screw (E).
5. Repeat "Check Procedure".

## Choke Cable Adjustment

### Reason:

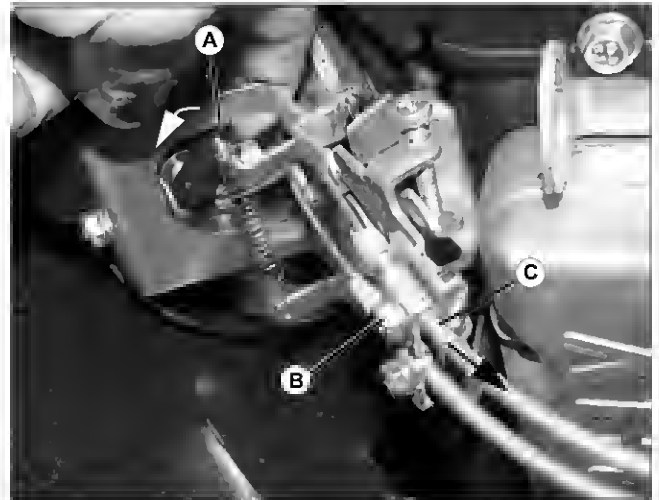
To make sure the choke is fully closed when the choke control lever is in the full choke position.

### Check Procedure:

1. Park machine on a flat surface. Turn engine OFF and engage parking brake.
2. Allow engine to cool.
3. Place and hold the choke control lever on control panel in the full choke position.



**Caution: Avoid Injury! Engine components may be HOT. Allow engine to cool before making adjustments. Do not touch, exhaust pipe or muffler while making adjustments**



4. With the control panel choke lever held in the full choke position, try and turn carburetor choke lever (A) clockwise with your finger. If the carburetor choke lever can be turned further, the choke is not fully closing and choke cable should be adjusted.

### Adjustment:

1. Loosen choke cable clamp screw (B).
2. While holding control panel choke lever in the full choke position, pull choke cable housing (C) toward outside of machine (arrow) as far as it will go, and retighten clamp screw.
3. Perform check procedure again to verify adjustment.

# ENGINE - KAWASAKI (FS541V) TESTS AND ADJUSTMENTS

## Governor Static Adjustment

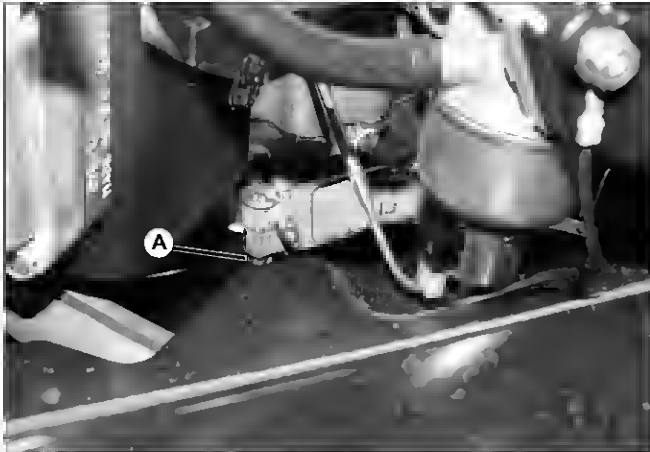
### Reason:

To ensure the governor linkage is set correctly after any work has been performed on the engine that may have disturbed governor linkage.

### Procedure:

**Note: This procedure is done with engine stopped.**

1. With engine off, move throttle control lever to FAST idle position.



MX43647

2. Loosen nut (A) on pinch bolt.



MX43648

3. Insert a small allen wrench in hole in governor shaft (B) and turn shaft counter clockwise as far as it will go.
4. Governor spring should be pulling up on end of governor arm. Make sure end of governor arm is up to the end of travel and carburetor throttle control is in wide open position. Hold in position with your finger if necessary.
5. Hold governor shaft and governor arm in place and tighten pinch bolt nut (A) to **7.8 N•m (69 lb-in.)**.

6. Move throttle control lever through full range to be sure linkage is not binding.

## Slow Idle Speed Adjustment

### Reason:

The slow idle speed is adjustable. Slow idle is governed at **1850 ± 150 rpm**.

The idle mixture screw can be adjusted within limiter range, and the slow idle stop can be set.

### Equipment:

- JT07270 Digital Pulse Tachometer; or,
- JT05719 Photo Tachometer

### Procedure:

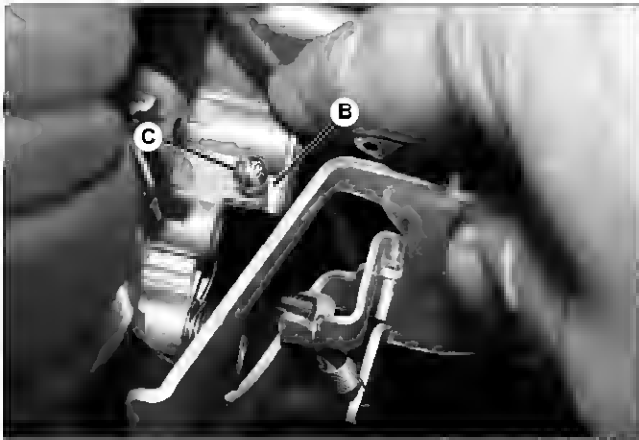
1. Park machine safely.
2. Put reflective tape (if using photo tachometer) on blower housing screen.



MX43651

3. Start and run engine at MEDIUM idle for five minutes.
4. Move throttle control lever to SLOW idle position.
5. Turn idle mixture screw (A) slowly back and forth between the limit stops until best idle is obtained.

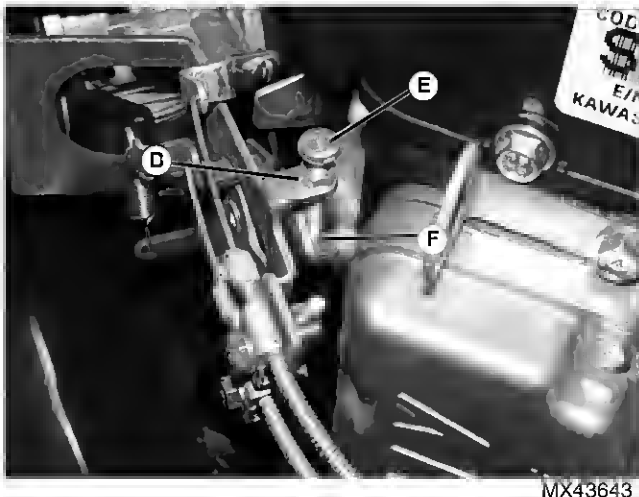
# ENGINE - KAWASAKI (FS541V) TESTS AND ADJUSTMENTS



6. Hold the throttle lever on the carburetor in the closed position so that tab (B) is against low speed screw (C) and check engine speed with tachometer.

7. Slow idle speed should be 1450 rpm. If it is not, maintain pressure against low speed screw, and adjust screw until rpm is 1450.

**Note:** Low idle speed is governed at  $1850 \pm 100$  rpm. When throttle lever is released, the engine will speed up and the carburetor idle stop screw should not be in contact with throttle tab.



8. Release the throttle on the carburetor. Check engine speed with tachometer and compare to specification.

9. If rpms are not within specification loosen jam nut (D) and back out slow speed limit screw (E) a few turns.

10. Move throttle lever on dash until correct governed slow idle speed is obtained. Throttle cable may have to be adjusted to increase travel of throttle control arm.

11. When correct idle speed is obtained turn the low idle speed screw (E) on the control plate until it touches the tab (F) on the throttle control arm. Hold screw and tighten jam nut.

## Specification

Governed Low Idle . . . . .  $1850 \pm 100$  rpm

## Fast Idle Speed Adjustment

### Reason:

To set engine fast idle speed setting.

### Equipment:

- JT07270 Digital Pulse Tachometer; or,
- JT05719 Photo Tachometer

### Procedure:

1. Park machine safely. See "Park Machine Safely" in the Safety section.
2. Put reflective tape (if using photo tachometer) on blower housing screen.
3. Start and run engine at MEDIUM idle for five minutes to warm engine.

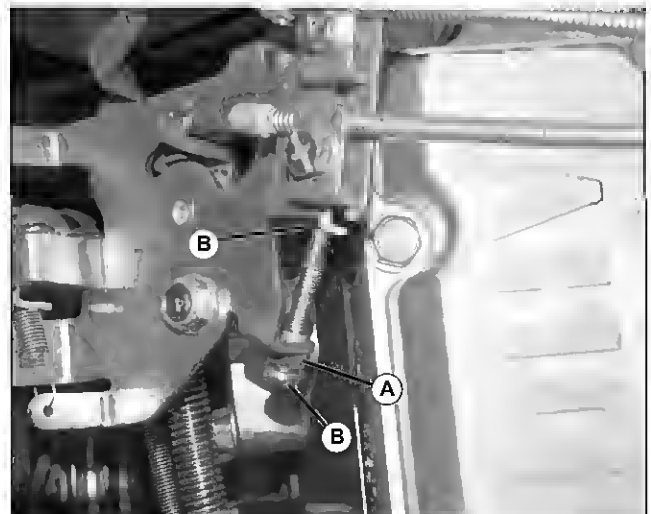


**Caution: Avoid Injury! Engine will be HOT. Be careful not to burn hands.**

4. Move throttle control lever to FAST idle position.
5. Check engine speed with tachometer and compare to specification.

### Results:

If fast idle speed does not meet the specifications:



1. Loosen jam nut (A).
2. Back out high speed limit screw (B) a few turns.
3. Move throttle lever on dash until correct fast idle speed is obtained. Throttle cable may have to be adjusted to

# ENGINE - KAWASAKI (FS541V) TESTS AND ADJUSTMENTS

increase travel of throttle control arm.

4. When correct fast idle speed is obtained turn the fast idle speed limit screw (B) on the control plate until it touches the tab (C) on the throttle control arm. Hold screw and tighten jam nut.

5. Stop engine.

## Specification

**Fast Idle rpm . . . . . 3100 ±100 rpm**

## Valve Clearance Adjustment

### Reason:

To obtain the proper valve clearance that is critical for the valves to seat properly and the automatic compression release to work correctly.

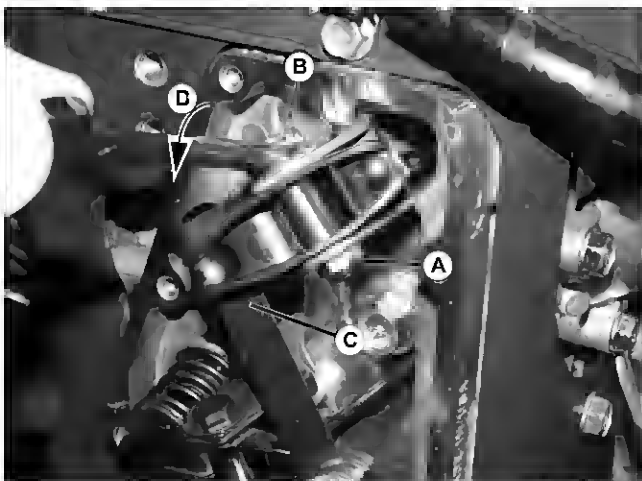
### Equipment:

- Feeler Gauge (blade type)

### Procedure:

**Important: Avoid Damage! Perform valve clearance check or adjustment when engine is cold.**

1. Park machine safely. See "Park Machine Safely" in the Safety section.
2. Turn key switch OFF. Allow engine to cool.
3. Remove and ground spark plug leads. Remove spark plugs.
4. Remove valve covers.
5. Turn crankshaft until piston, visible in spark plug hole is at TDC (top dead center) of the compression stroke (both intake and exhaust valves will be closed).



MX43023

6. Loosen nut (A) and valve adjusting cap screw (B). Adjusting cap screw is eccentric, so when turned changes

valve clearance.

7. Insert a 0.10-0.15 mm (0.004-0.006 in.) feeler gauge (C) between the rocker arm and valve stem. While moving the feeler gauge back and forth, turn the adjusting cap screw forward (D) until a slight drag can be felt on the feeler gauge.

8. Hold the adjusting cap screw in this position with a wrench while tightening the nut to the specified torque.

9. Recheck clearance after tightening nut. Readjust if necessary

10. Repeat procedure on other cylinder.

11. Install valve covers and spark plugs.

## Specification

**Valve Clearance . . . . . 0.10mm (0.004 - 0.006 in.)**

**Adjuster Nut Torque . . . . . 11 N•m (87 lb-in.)**

**Valve Cover Cap Screw Torque . . . . 5.9 N•m (52 lb-in.)**

**Spark Plug Torque . . . . . 22 N•m (195 lb-in.)**

## Cylinder Compression Pressure Test

### Reason:

To determine the condition of the pistons, rings, cylinder walls, and valves.

### Test Equipment:

- JDM59 Compression Gauge

### Procedure:

1. Valve clearance must be adjusted properly before doing a compression test.
2. Run engine for five minutes to bring engine to operating temperature.
3. Park machine safely.
4. Remove spark plugs.

# ENGINE - KAWASAKI (FS541V) TESTS AND ADJUSTMENTS



5. Install JDM59 compression gauge (A) in one spark plug hole.
6. Ground high tension leads (B).
7. Move throttle control lever to FAST idle position.
8. Check that choke is fully open and that air filter is clean.

**Important: Avoid Damage! DO NOT overheat starting motor during test. Starting motor duty cycle is 5 seconds ON, 10 seconds OFF.**

9. Crank engine for three to five compression strokes.
10. Record pressure reading.
11. Repeat test with other cylinder.

## Specifications:

**Minimum Compression . . . . . 390 kPa (57 psi)**  
**Maximum difference between cylinders. . 41 kPa (6 psi)**

**Note: Above specification is for an engine that has sufficient time to allow rings to fully seat. Compression that is lower than specifications on low hour machines (but relatively equal on both cylinders) probably does not indicate a problem.**

- If above specification, adjust valves and check fuel and air intake systems. Check exhaust for restriction.
- If below specification, squirt clean engine oil into cylinder and repeat test.
- If compression pressure DOES NOT increase after retest; check for leaking valves, valve seats, or cylinder head gaskets.
- If compression pressure INCREASES after retest; check rings, pistons, and cylinder bores for broken rings, scoring, wear or damage. Replace as necessary.

## Cylinder Leak-Down Test

### Reason:

To determine if compression pressure is leaking from cylinder.

### Test Equipment:

- JTO3502 Compression Leakdown Tester

### Procedure:

1. Start engine. Run for 5 minutes to bring it up to normal operating temperature.
2. Park machine safely. See "Park Machine Safely" in the Safety section.



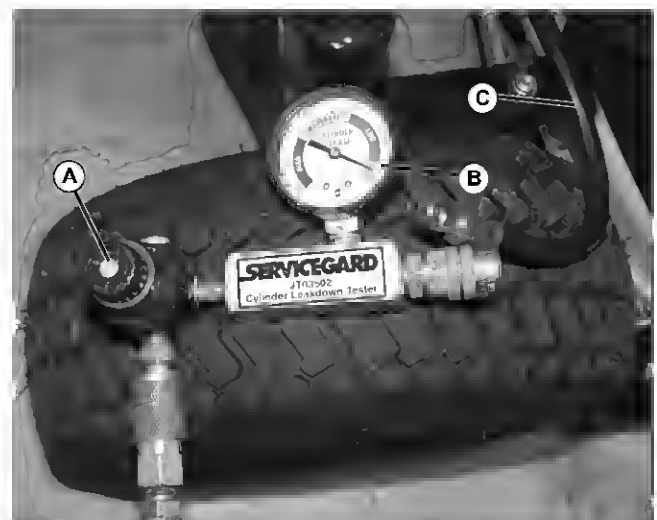
**Caution: Avoid Injury! Engine components are HOT. Be careful not to touch, especially the exhaust pipe or muffler while making adjustments. Wear protective eye glasses and clothing.**

3. Remove spark plugs.
4. Remove rocker arm covers.

**Note: The crankshaft must be held with the piston just slightly past TDC to seal the combustion chamber and eliminate the chance of rotation. Screw the adapter hose (D) into the spark plug hole, but do not attach it to the tester at this time.**

5. Turn crankshaft until piston, visible in spark plug hole, is at TDC of the compression stroke (both intake and exhaust valves will be closed).

**Note: The air supply must have enough supply pressure to calibrate the tester, usually 585 - 655 kPa (85 - 95 psi).**



# ENGINE - KAWASAKI (FS541V) TESTS AND ADJUSTMENTS

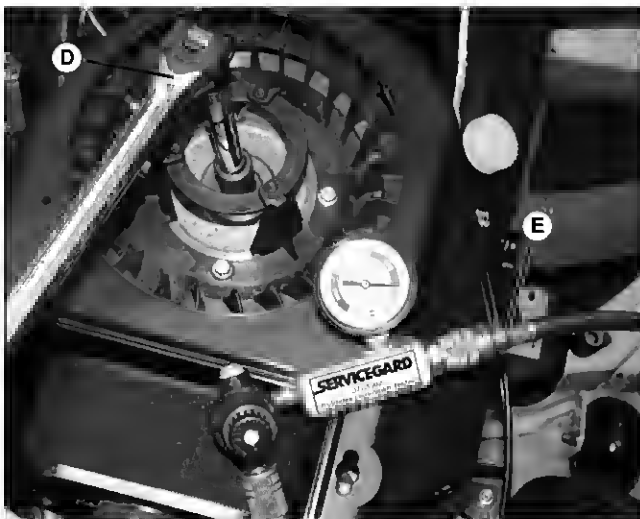
6. Connect tester port to an air source.
7. Install threaded end of tester hose (C) into spark plug hole of cylinder to be tested.

**Note:** *Air leaks at any of the connections or fittings of the tester will affect the accuracy of the test.*

8. Pull back the locking ring and slowly rotate the regulator adjustment knob (A) until the gauge needle is in the SET range of the gauge (B). Push the locking ring towards the tester to lock knob in position.



**Caution: Avoid Injury!** Injury can occur if the crankshaft is not locked in position. The air source can create a rotational force of up to 60 lb-ft (81 N•m) if the crankshaft is not locked with the piston slightly past top dead center.



MX44067

9. Have an assistant hold the crankshaft in position with a socket and breaker bar (D). Connect the adapter hose (E) to the tester, and record the needle position.

**Note:** *A small amount of air escaping from the crankcase breather is normal. If a high flow of air is leaking from the exhaust or carburetor areas, make sure that piston is just slightly past TDC of the compression stroke.*

10. Observe reading on gauge. Listen for air leaking from the cylinder head gasket, carburetor, exhaust system and either the crankcase breather or oil fill/ dipstick tube.

## Results:

- Gauge reading in the Green (low) area indicates good compression. (Less than 25% leakage is considered normal).
- Gauge reading in the Yellow (Moderate) area indicates

borderline compression. The engine is still usable but an overhaul or replacement should be considered.

- Gauge reading in the Red (High) area indicates excessive compression loss. Engine reconditioning or replacement is necessary.
- Check for air escaping from muffler, air cleaner or oil fill opening.
- Excessive air escaping from the crankcase breather indicates worn piston rings or cylinder wall.
- Air escaping from the carburetor indicates a worn intake valve or seat.
- Air escaping from the exhaust pipe indicates a worn exhaust valve or seat.
- Repeat test on other cylinder.



# ENGINE - KAWASAKI (FS541V) TESTS AND ADJUSTMENTS

## Crankcase Vacuum Test

### Reason:

To measure the amount of crankcase vacuum, which ensures the crankcase is not pressurized. A pressurized crankcase will force oil leakage past the seals and gaskets and affect fuel pump operation.

### Test Equipment:

- 8741-F66 Plug
- JT05703 Barb Fitting
- JT05699 Line
- JT05698 U-Tube Manometer

or,

- JT03503 Crankcase Vacuum Test Kit

### Procedure Using JT05698 U-Tube Manometer:

1. Park machine safely. See "Park Machine Safely" in the Safety section.
2. Engage parking brake.
3. Remove dipstick.

**Important: Avoid Damage! DO NOT make connection between U-Tube manometer and engine BEFORE engine is running or fluid in manometer could be sucked into crankcase. DO NOT turn engine OFF until Line has been disconnected from manometer.**

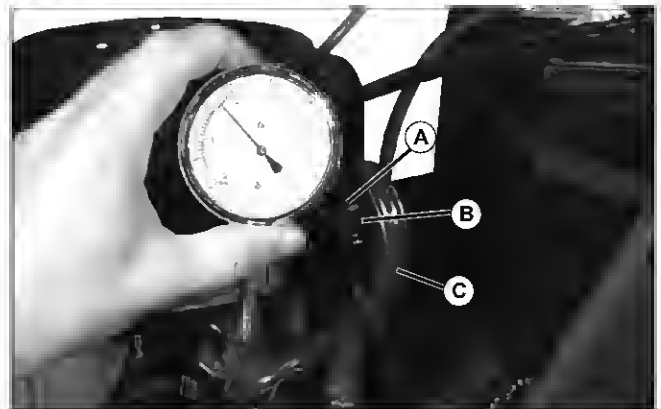
4. Start and run engine at slow idle.
5. Install 8741-F66 Plug in dipstick hole.
6. Install JT05703 barbed fitting in plug and connect JT05699 Line.
7. Connect JT05698 manometer to Line.
8. Run engine at fast idle.
9. Open manometer vent and record crankcase vacuum reading. manometer should show a vacuum of **1.25 - 25 cm (0.5 - 10 in.)** of water at fast idle.
10. Run engine at slow idle (**1850 ± 75 rpm**). DO NOT TURN ENGINE OFF!
11. Disconnect Line from manometer.
12. Turn engine OFF.
13. Remove barbed fitting and plug from dipstick tube and install dipstick.

### Procedure Using JT03503 Crankcase Vacuum Kit:

1. Park machine safely. See "Park Machine Safely" in the Safety section.
2. Check dipstick/oil fill cap and o-ring for cracks or damage, replace as necessary.
3. Install appropriate size rubber plug in dipstick tube.
4. Insert barbed fitting (E) in rubber plug (F) so that clear line (G) to fitting can be connected at a later step.

**Important: Avoid Damage! DO NOT make connection between test gauge and rubber plug BEFORE engine is running at FAST idle or gauge damage may result.**

**After test reading is made, DO disconnect test gauge WHILE engine is running at FAST idle to prevent damage to gauge.**



M99563

5. Hold finger over rubber plug hole to keep oil from spraying out. Start engine, move the throttle lever to fast idle and allow engine to reach operating temperature.
6. Connect gauge, clear line (C), and barbed fitting (A) to rubber plug (B).
7. Record crankcase vacuum reading. Gauge should show a vacuum of **1.25 - 25 cm (0.5 - 10 in.)** of water at fast idle (**3100 ± 50 rpm**).
8. Disconnect barbed fitting, clear line, and gauge from rubber plug while engine is running at FAST idle. Hold finger over rubber plug hole to keep oil from spraying out.
9. Move throttle to SLOW idle and turn engine OFF.
10. Remove rubber plug and install dipstick.

### Specification:

**Crankcase Vacuum at high idle 1.25 - 25 cm (0.5 - 10 in.) of water**

**Note: A new engine may have low vacuum readings due to the fact that the rings are not fully seated.**

# ENGINE - KAWASAKI (FS541V) TESTS AND ADJUSTMENTS

## Results:

- If crankcase vacuum is BELOW specifications, check the following:
  - Breather reed valve clearance and condition.
  - Seals and gaskets for leakage.
  - Fuel pump vacuum hose leakage.
  - Rings, piston, and cylinder bore for wear or damage.

## Engine Oil Pressure Test

### Reason:

To verify if the engine has enough oil pressure to lubricate internal components.

### Test Equipment:

- JT03344 Pressure Gauge Assembly
- JT03017 Hose Assembly
- JT03349 Connector

### Procedure:

1. Park machine safely.



**Caution: Avoid Injury! Engine components are HOT. Be careful not to touch, especially the exhaust pipe or muffler while making adjustments. Wear protective eye glasses and clothing.**

2. Turn key switch OFF. Allow engine to cool.
3. Check engine oil level. Bring level to full mark.



4. Remove oil plug (A).
5. Install JT03349 Connector.
6. Connect JT03017 hose assembly and JT03344 pressure gauge assembly.

7. Monitor oil pressure while cranking engine. If no oil pressure is present, discontinue cranking engine. Determine and correct the cause before running engine.

**Important: Avoid Damage! If pressure reading is below 69 kPa (10 psi), STOP ENGINE IMMEDIATELY and determine cause.**

8. Start and run engine at MEDIUM idle for five minutes to heat engine oil to normal operating temperature.
9. Run engine at fast idle and check oil pressure.

**Note: Use silicon sealer on switch threads.**

10. Remove test equipment.
11. Put thread sealant on plug and install plug to engine. Tighten plug to specification.

### Results:

If oil pressure is BELOW specifications, inspect or replace the following:

- Oil pressure relief valve for broken or worn spring.
- Oil pressure relief valve for stuck or damaged valve.
- Worn or damaged oil pump.
- Oil pump suction screen or oil passages plugged.
- Excessive wear of connecting rod and main bearings or journals.
- Oil filter plugged.

### Results:

If oil pressure is ABOVE specifications, inspect or replace the following:

- Oil pressure relief valve for sticking.
- Ensure that oil type and viscosity is correct.

### Specifications:

**Oil Pressure . . . . . 294 - 686 kPa (43 - 99 psi)**

# ENGINE - KAWASAKI (FS541V) TESTS AND ADJUSTMENTS

## Fuel Pump Test

### Reason:

To check condition of fuel pump and determine fuel pressure.

### Test Equipment:

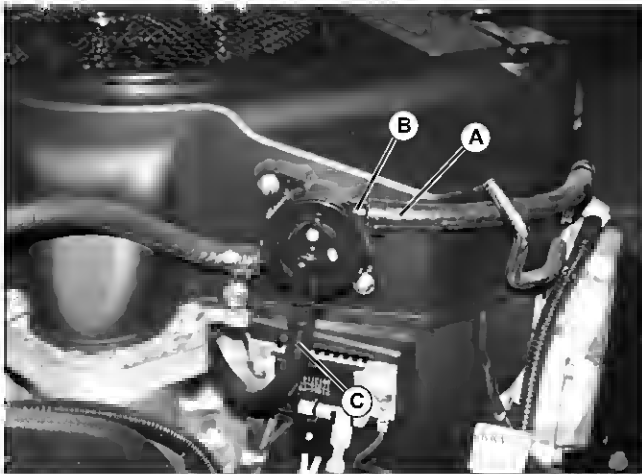
- JDG356 Pressure Gauge
- Graduated Container

### Procedure:

1. Park machine safely.
2. Turn key switch OFF.
3. Lock parking brake.



**Caution: Avoid Injury! Gasoline is extremely flammable. DO NOT SMOKE. Always work in a well ventilated area away from open flame or spark producing equipment; this includes equipment that utilizes pilot lights.**



MX43659

4. Disconnect and plug fuel pump outlet hose (A).
5. Connect JDG356 pressure gauge to fuel pump outlet (B).
6. Start and run engine at fast idle for 15 seconds, then record pressure reading.
7. Stop engine.
8. Remove pressure gauge from fuel pump outlet and connect a length of hose long enough to reach into a graduated container.
9. Start and run engine at fast idle for 15 seconds, then stop the engine and record container measurement.

### Results:

If fuel pump pressure or flow does not meet the

specifications, check the following:

- Fuel lines, vacuum line (C), fuel filter and fuel tank cap for restrictions.
- Check fuel pump vent holes for obstruction.
- Check crankcase vacuum.
- Replace fuel pump.

### Specifications:

**Fuel Pump Pressure (Slow Idle) . . . . 2.45 kPa (0.36 psi)**

**Minimum Fuel Flow . . . . . 65 mL (2.2 oz)/15 seconds**

## Spark Test

### Reason:

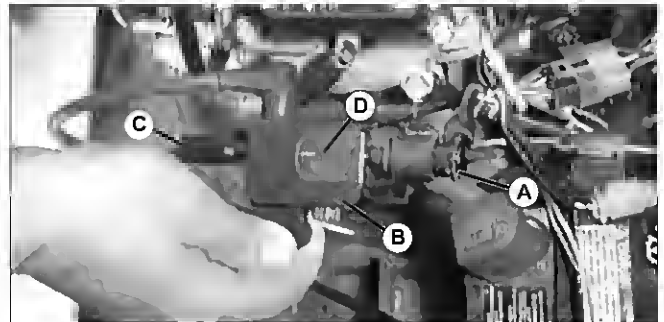
Check overall condition of ignition system.

### Test Equipment:

- D-05351ST Spark Tester

### Procedure:

1. Park machine safely. See "Park Machine Safely" in the Safety section.
2. Turn key switch OFF.
3. Move forward/reverse pedals to NEUTRAL position. Engage parking brake.



M56821

4. Remove high tension lead (A) from spark plug.
5. Connect D-05351ST spark tester (B) to spark plug.
6. Connect high tension lead to spark tester.

**Important: Avoid Damage! Do not adjust spark tester gap beyond 5.0 mm (0.200 in.) (5 turns), as damage to ignition components could occur.**

7. Adjust spark tester gap to 4.2 mm (0.166 in.) (4 turns) with screw (C).
8. Crank engine and watch spark (D) at spark tester. If engine will start, watch spark with engine running. A steady, strong blue spark should be observed.

# ENGINE - KAWASAKI (FS541V) TESTS AND ADJUSTMENTS

## Results:

- If spark is weak, or no spark is present, install a new spark plug and repeat test.
- If spark is still weak, or no spark is present, run tests on individual components to find the cause of the malfunction.

## Spark Plug Gap Adjustment

### Equipment:

- Feeler Gauge, or
- Wire Gauge

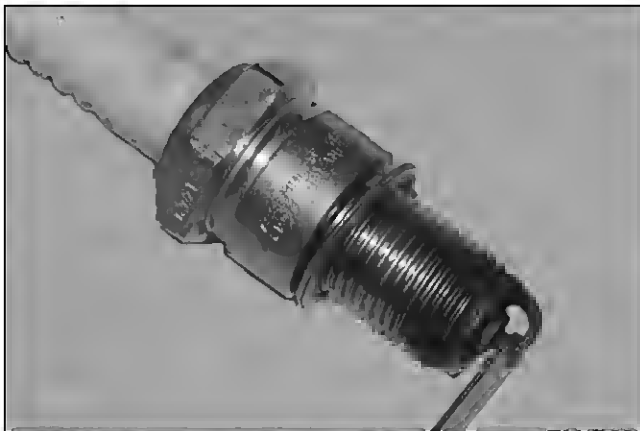
### Procedure:

1. Park machine safely. See "Park Machine Safely" in the Safety section.



**Caution: Avoid Injury! Engine components may be HOT. Be careful not to touch, especially the exhaust pipe or muffler while making adjustments.**

2. Remove spark plugs.
3. Inspect spark plug for cracked porcelain and pitted or damaged electrodes.



MX42563

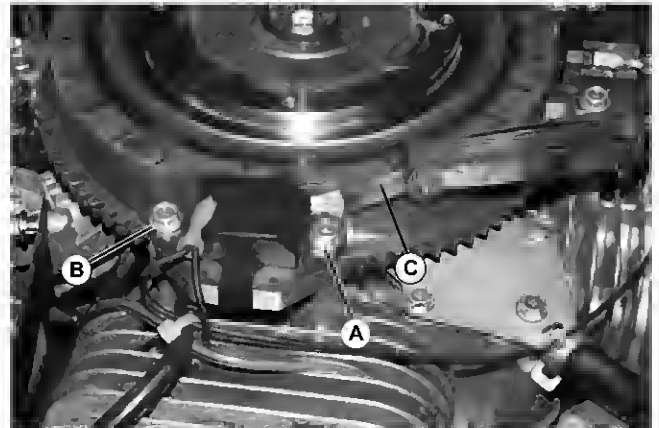
4. Check spark plug gap using a feeler or wire gauge. Set gap to specification.
5. Install and tighten spark plug to specification.

### Specifications:

Spark Gap ..... 0.76 mm (0.030 in.)  
Spark Plug Torque ..... 22 N•m (195 lb-in.)

## Ignition Coil Air Gap Adjustment

1. Center flywheel magnet under armature and coil.



MX44078

2. Loosen cap screws (A) and (B).
3. Insert a 0.30 mm (0.012 in.) feeler gauge (C) between flywheel and armature.
4. Push armature against flywheel and tighten cap screws.
5. Turn flywheel to remove feeler gauge and center flywheel magnet under coil and second armature.
6. Repeat setting air gap for second armature. Tighten cap screws.
7. Rotate flywheel fully around and check both air gap measurements.
8. Tighten cap screws to specification.

### Specifications:

Ignition Coil Air Gap ... 0.2 - 0.4 mm (0.008 - 0.016 in.)  
Cap Screw Torque ..... 5.9 N•m (52 lb-in.)

# ENGINE - KAWASAKI (FS541V) REPAIR

## Repair

### Engine Removal and Installation

#### Removal:



**Caution: Avoid Injury! Engine components may be HOT. Allow engine to cool before removing engine.**

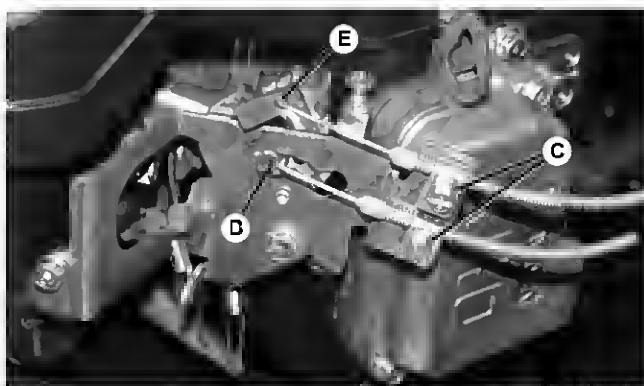
1. Park machine safely. See "Park Machine Safely" in Safety section.
2. Disconnect negative (-) cable from battery.
3. Remove mower deck. See the appropriate information in the Attachments section.



MX44085

#### Picture Note: Left Side

4. Disconnect plastic tie holding throttle/choke cables and ground cable to dipstick tube.(A).

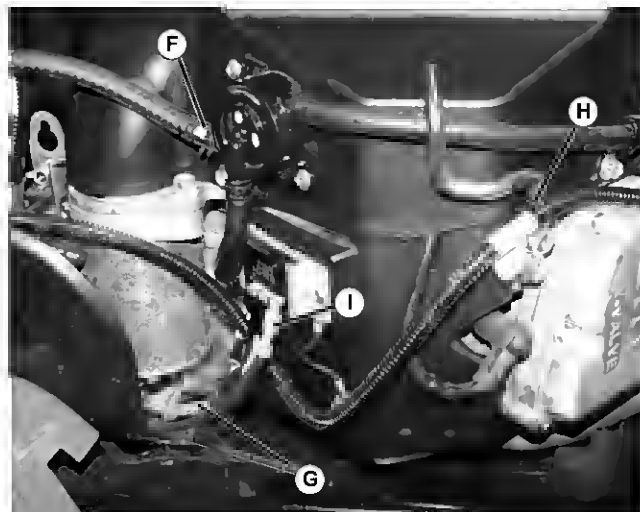


MX43645

5. Remove screws and cable retainers (C).
6. Unhook throttle cable (D) and choke cable (E).



**Caution: Avoid Injury! Gasoline is extremely flammable. DO NOT SMOKE. Always work in a well ventilated area away from open flame or spark producing equipment; this includes equipment that utilizes pilot lights.**



MX44086

#### Picture Note: Right Side

7. Disconnect and plug fuel line (F) from fuel pump.
8. Disconnect connectors (G) for fuel shutoff solenoid and magneto kill wires.
9. Disconnect tie wrap (H) securing headlight wiring to engine.
10. Disconnect wire (I) from regulator/rectifier.



MX44087

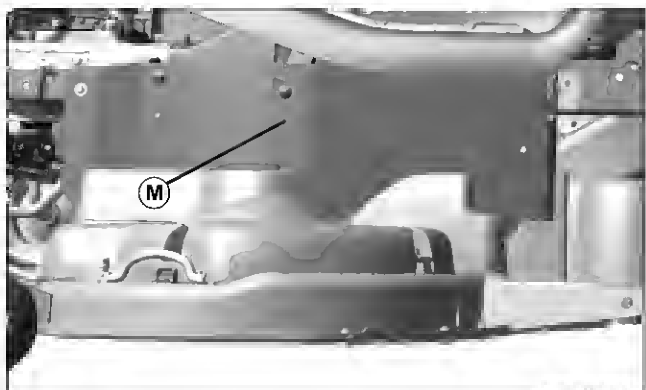
11. Disconnect ground cable (J) from engine block.
12. Disconnect cable (K) from starting motor terminal.

## ENGINE - KAWASAKI (FS541V) REPAIR



MX44088

13. Remove cap screws (L) securing starter solenoid to engine lifting bracket.



MX43926

14. If equipped, remove side shields (M).

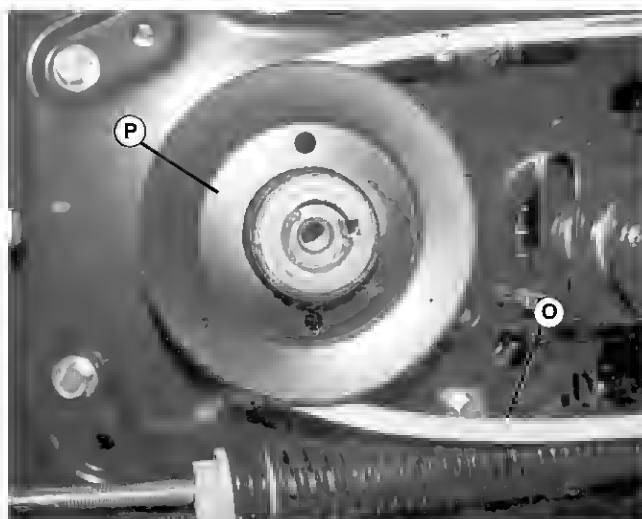


MX43930

15. If equipped, remove PTO clutch shield (N).

16. Remove electric PTO clutch. See "PTO Clutch Removal and Installation" in the Power Train section.

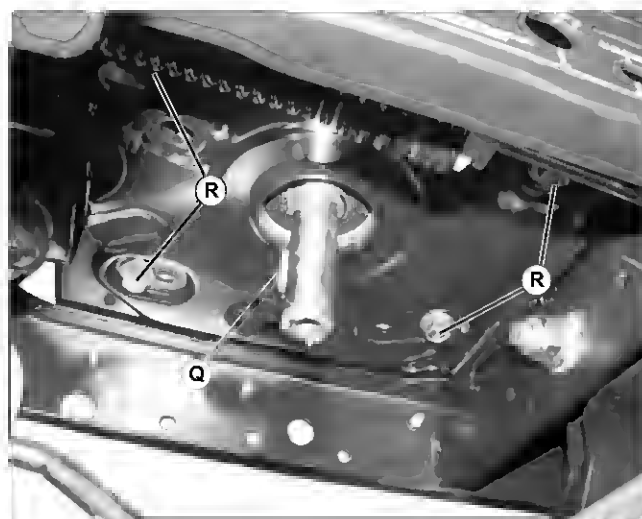
17. Remove muffler. See "Muffler Removal and Installation" on page 195.



MX38340

18. Remove drive belt (O) from drive sheave (P).

19. Remove drive sheave from end of crankshaft.



MX38341

20. Remove key (Q) from crankshaft.

21. Remove four engine mounting cap screws (R).

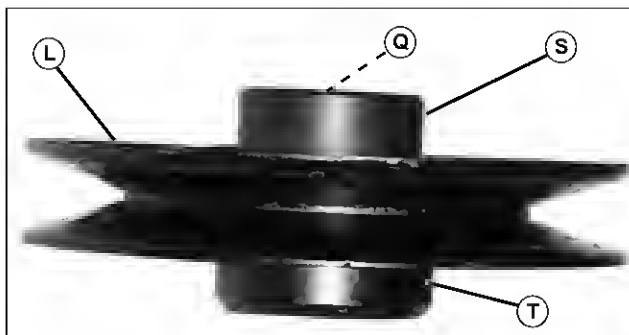
22. Remove engine.

### Installation:

Installation is done in the reverse order of removal.

1. Install four engine mounting cap screws. Tighten cap screws to specifications.
2. Connect ground wire to right rear of engine and secure with cap screw.
3. Apply MPG-2 Multipurpose Polymer Grease to engine crankshaft.

# ENGINE - KAWASAKI (FS541V) REPAIR



MX37051

4. Install traction drive sheave (P) with key (Q). Be sure to install small hub (S) against engine and large hub (T) to clutch.
5. Install traction drive belt around drive sheave.
6. Install electric PTO clutch. See "PTO Clutch Removal and Installation" in the Power Train section.
7. Connect the fuel line to the fuel pump.
8. Install starter solenoid to engine lift bracket and connect the (+) wire from the solenoid to the starting motor.
9. Connect engine wiring.
10. Connect the throttle and choke cables and secure with cable clamp.
11. Adjust throttle and choke cables. See "Throttle Cable Check and Adjustment" on page 178 and "Choke Cable Adjustment" on page 179.
12. Install muffler. See "Muffler Removal and Installation" on page 195.
13. Install mower. See "Installing Mower" in the Attachments section.
14. Check engine oil level.

## Specifications:

**Engine Mounting Cap Screw Torque . 34 N•m (25 lb-ft)**  
**Oil Capacity w/ Filter (Approximate). . . . . 1.7 L (1.8 qt)**

## Carburetor Removal, Disassembly, and Installation

### Removal:

1. Remove air cleaner cover.

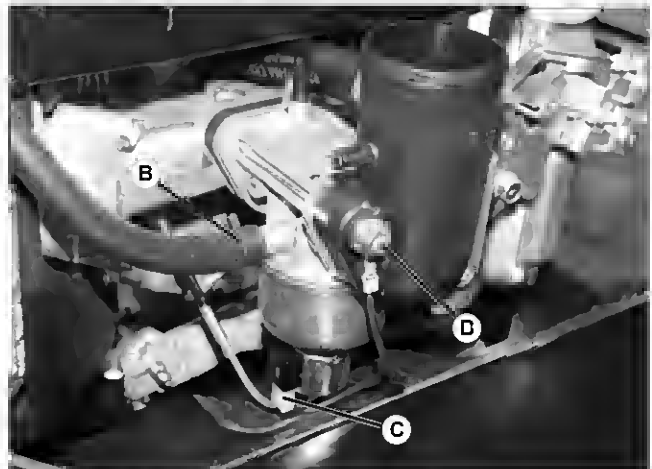


MX44068

2. Loosen clamp (A) on air filter elbow and remove filter and elbow.

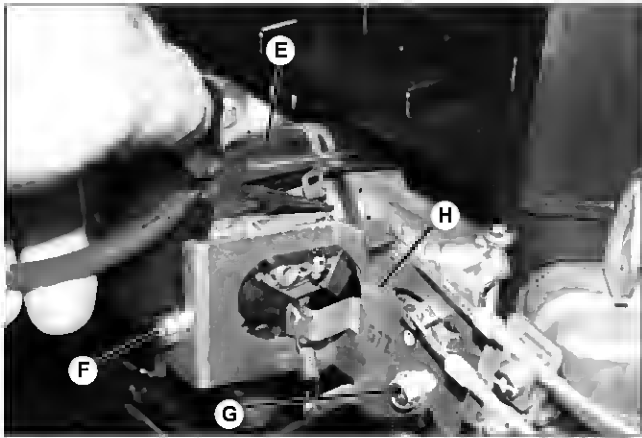


**Caution: Avoid Injury! Gasoline is extremely flammable. Do not smoke. Always work in a ventilated area away from open flame or spark producing equipment, including equipment that utilizes pilot lights.**

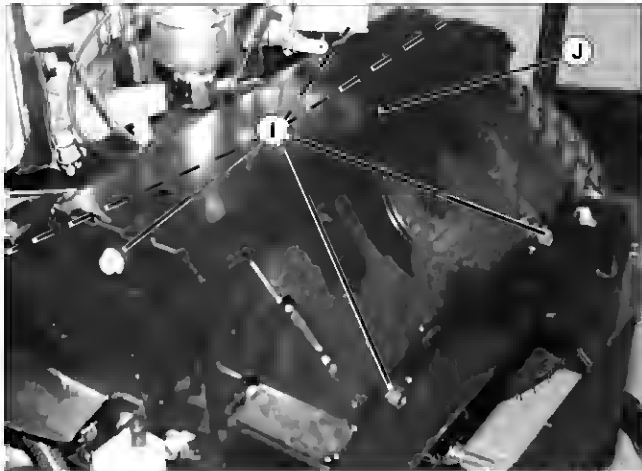


3. Disconnect fuel line (B) and fuel shutoff solenoid (C). Remove nut (D) from carburetor elbow.

# ENGINE - KAWASAKI (FS541V) REPAIR



4. Disconnect breather hose (E). Remove other carburetor elbow nut (F) and bolt (G) from control bracket. Move the control bracket (H) aside.



5. Remove six screws (I) and upper heat shield (J).



6. While pulling the carburetor forward disconnect the throttle link and throttle spring (K) from the carburetor.

**Note:** Governor rod spring and governor rod go in same hole in throttle shaft arm on carburetor.

Installation is done in the reverse order of removal.

- Always use new gaskets.
- Tighten fasteners to specification.
- Check low and high idle speed settings and adjust if necessary.

## Torque Specifications:

Control Panel Mounting Screws . . . 5.9 N•m (52 lb-in.)

Carburetor Nuts . . . . . 5.9 N•m (52 lb-in.)

## Disassembly:



**Caution: Avoid Injury!** Gasoline is extremely flammable. Do not smoke. Always work in a ventilated area away from open flame or spark producing equipment, this includes equipment that utilizes pilot lights.

**Important: Avoid Damage!** To remove float, use a long nosed pliers on end of float pin. Do not strike opposite end of pin. Damage to pin holder may result.

1. Refer to component illustration shown for component location.
2. There are several passage plug balls in carburetor body. DO NOT remove these plugs.
3. When removing the idle mixture screw, carefully mark the position of the idle mixture screw limiter on the carburetor body so that it can be installed and set to its original position later.
4. Remove limiter. Be careful not to idle mixture air screw at this point.
5. Turn the idle mixture screw clockwise and count the number of turns until screw is gently seated in the pilot passage.
6. Record the number of turns needed to close the idle mixture screw.
7. Turn out the idle mixture screw and replace with a new one.

## Clean/Inspect/Rebuild:

**Important: Avoid Damage!** Do not clean holes or passages with small drill bits or wire.

**Note:** If all rubber and plastic parts cannot be removed for cleaning, use a cleaning solvent with a high flash point that will not damage these parts when cleaning.

1. Remove rubber and plastic parts from carburetor. Soak all carburetor metal parts in carburetor cleaning solvent for



# ENGINE - KAWASAKI (FS541V) REPAIR

1/2 hour maximum.

2. Spray all passages with a carburetor cleaning spray to verify that all internal passages are open.



**Caution: Avoid Injury! Reduce compressed air to less than 210 kPa (30 psi) when using for cleaning purposes. Clear area of bystanders, guard against flying chips, and wear personal protection equipment including eye protection.**

**Important: Avoid Damage! Rinse carburetor body in warm water to neutralize corrosive action of cleaner on aluminum.**

3. Rinse carburetor with warm water and dry with compressed air. Do not use rags or paper to dry parts; lint may plug holes or passages.

4. Inspect all parts for wear or damage, replace as necessary.

**Note: Main jet high altitude kits are available.**

## Assembly:

1. Install new pilot air screw until screw is gently seated.
2. Then open the screw the same number of turns as recorded prior to removal.
3. Align the limiter with the mark on the carburetor body to install, taking care not to turn the pilot air screw.
4. Install the throttle valve on the shaft with numerical mark on the valve facing to the outside.
5. Note the metering hole in the choke valve. Install the choke valve on the shaft so that the metering hole is towards outside of the carburetor.
6. Install the float pin so that it's big diameter side faces the engine flange side. Float is plastic. The float cannot be adjusted. Replace if necessary.
7. Tighten all fasteners to specifications listed.

## Installation:

1. Installation is the reverse of removal.
2. Clean the carburetor and intake manifold mating surfaces.
3. Use new gaskets during installation.
4. Slide the carburetor about halfway onto the mounting studs. Attach throttle link and spring, then slide the rest of the way onto studs. Install carb elbow and throttle control plate. Tighten fasteners to specification.
5. Perform governor adjustment. See "Governor Static Adjustment" on page 180.

6. Adjust slow idle speed if necessary. See "Slow Idle Speed Adjustment" on page 180.

7. Check fast idle speed and adjust if necessary. See "Fast Idle Speed Adjustment" on page 181.

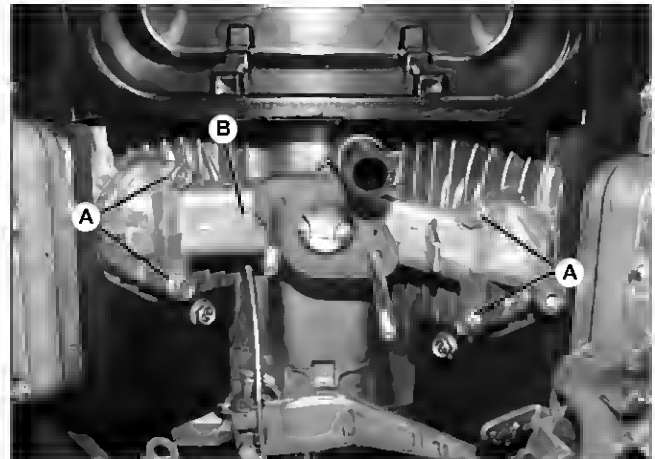
## Specifications:

Choke Valve Screws	0.7 N•m (6 lb-in.)
Throttle Valve Screws	1.0 N•m (9 lb-in.)
Pilot Jet	1.7 N•m (15 lb-in.)
Main Jet	0.7 N•m (6 lb-in.)
Valve Seat	2.0 N•m (17 lb-in.)
Main Nozzle	2.0 N•m (17 lb-in.)
Main Air Jet	0.7 N•m (6 lb-in.)
Pilot Air Jet	0.7 N•m (6 lb-in.)
Drain Screw	1.3 N•m (11 lb-in.)
Fuel Shutoff Solenoid	4.5 N•m (40 lb-in.)

## Intake Manifold Removal and Installation

### Removal:

1. Remove carburetor assembly. See "Carburetor Removal, Disassembly, and Installation" on page 191.



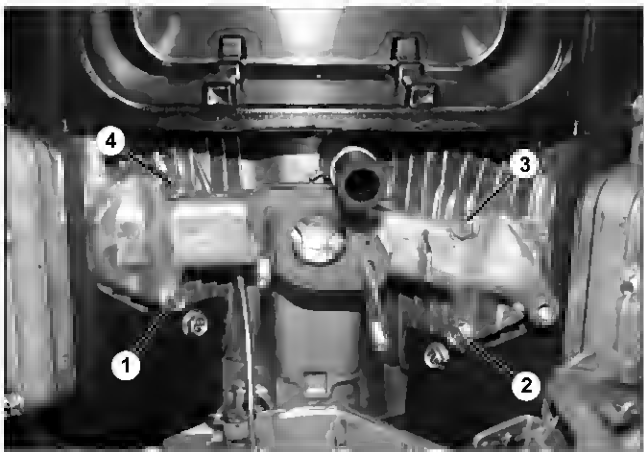
MX44091

2. Remove four cap screws (A) and the intake manifold (B).

### Installation:

1. Clean all old gasket material from intake manifold and cylinder head mating surfaces.
2. Install intake manifold with new gaskets.

# ENGINE - KAWASAKI (FS541V) REPAIR



3. Tighten cap screws to specification in the sequence shown.

## Specification

Intake Manifold Cap Screws . . . . . 5.9 N•m (52 lb-in.)

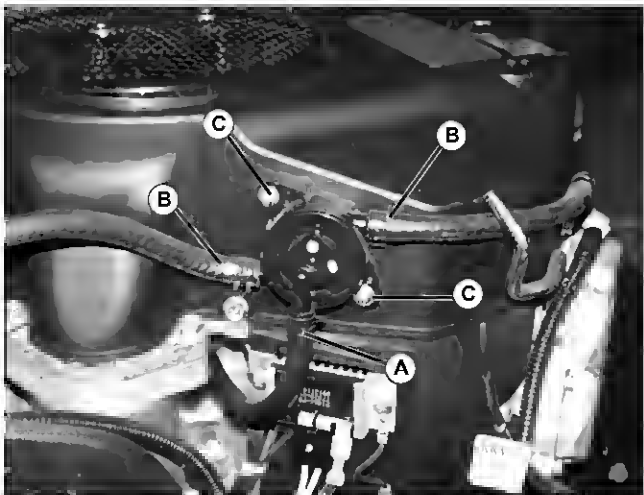
## Fuel Pump Removal and Installation

### Procedure:

1. Park machine safely. See "Park Machine Safely" in Safety section.



**Caution: Avoid Injury! Gasoline is extremely flammable. Do not smoke. Always work in a ventilated area away from open flame or spark producing equipment, this includes equipment that utilizes pilot lights.**



MX43659

2. Disconnect vacuum line (A) and fuel lines (B).
3. Remove two mounting screws (C).

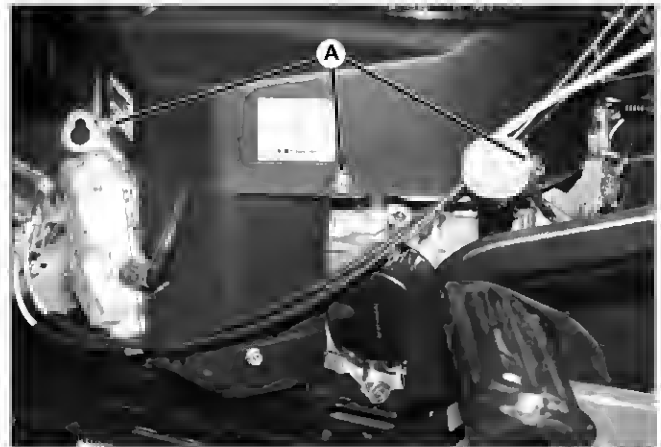
Installation is done in the reverse order of removal.

1. Install fuel pump.
2. Tighten mounting screws.

## Blower Housing Removal and Installation

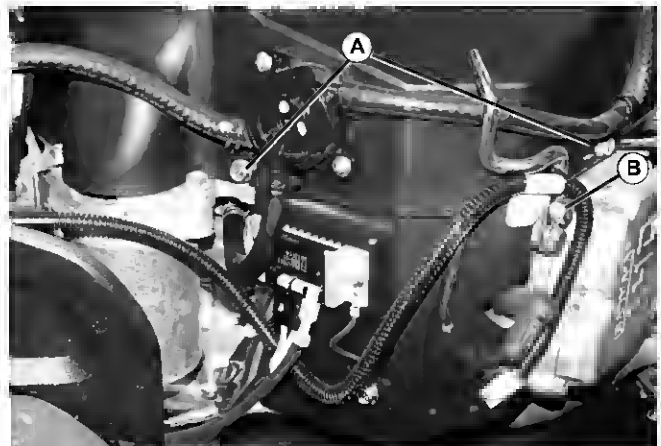
### Removal:

1. Remove three screws securing the flywheel screen to the flywheel. Remove flywheel screen.
2. Remove air filter cover and air filter.



MX44074

3. Remove three screws (A) on left side of the upper blower housing.



MX44073

4. Disconnect or remove fuel pump. See "Fuel Pump Removal and Installation" on page 194.
5. Remove two screws (A) on the right side of blower housing (I).
6. Loosen bolt (B) on fuel line protector.
7. Lift blower housing from engine.

### Installation:

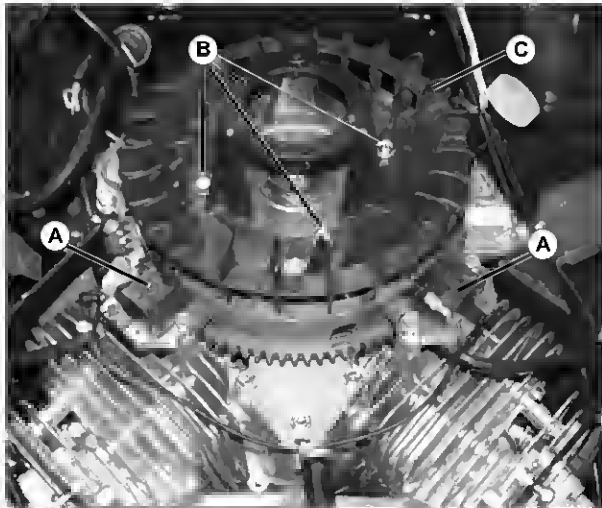
Installation is done in the reverse order of removal.

# ENGINE - KAWASAKI (FS541V) REPAIR

## Flywheel Removal and Installation

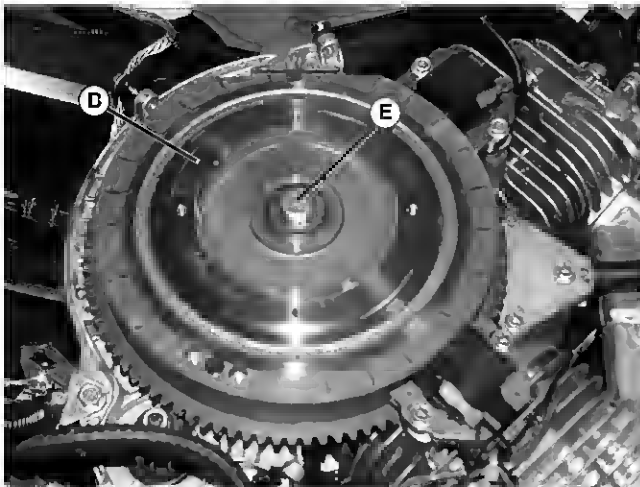
### Procedure:

1. Remove upper blower housing. See "Blower Housing Removal and Installation" on page 194.



MX44077

2. Remove both ignition coils (A).
3. Remove four bolts (B) and fan (C)



MX44076

4. Hold flywheel (D) and remove cap screw (E).
5. Remove flywheel using a flywheel puller.

### Installation is done in the reverse order of removal.

- Make sure flywheel key is in good shape and installed properly.
- Install flywheel and tighten cap screw to **56 N•m (41 lb-ft)**.
- Adjust ignition coil air gap. See "Ignition Coil Air Gap Adjustment" on page 188.

## Muffler Removal and Installation

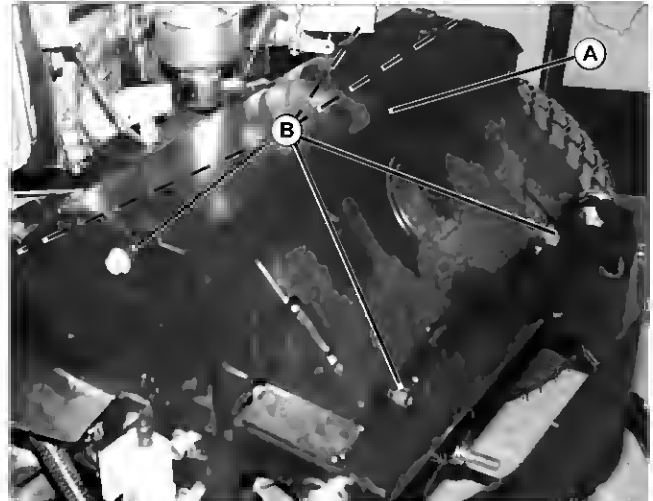
### Removal:

1. Park machine safely. See "Park Machine Safely" in Safety Section.



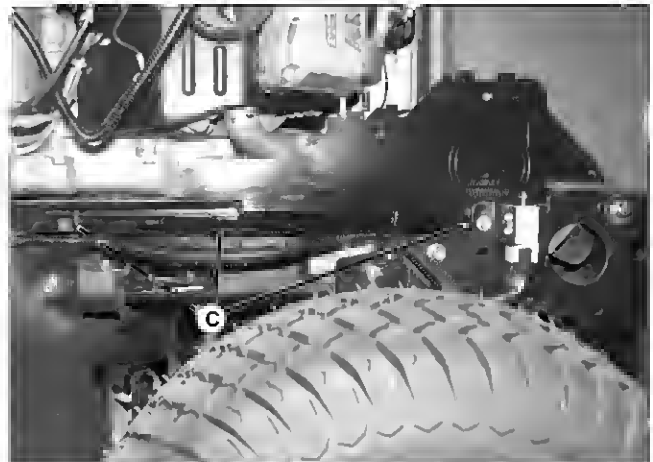
**Caution: Avoid Injury! To prevent possible burns, allow engine to cool before removing muffler**

2. Disconnect negative (-) cable from battery.



MX44071

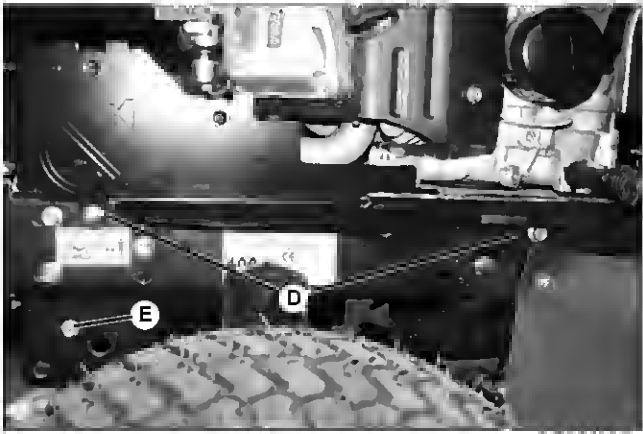
3. Remove six screws (B) securing top heat shield (A) to frame.



MX44079

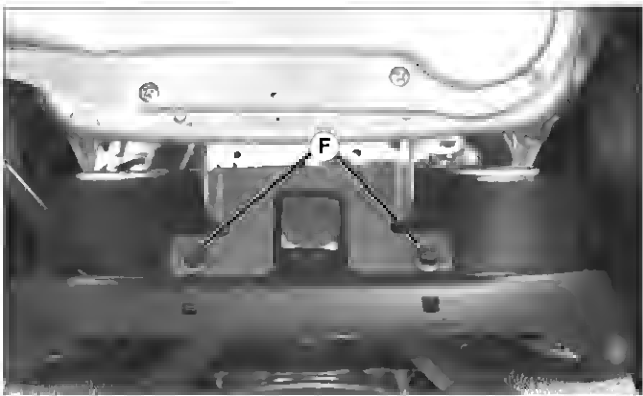
4. Remove three screws (C) securing right side heat shield to frame.

# ENGINE - KAWASAKI (FS541V) REPAIR



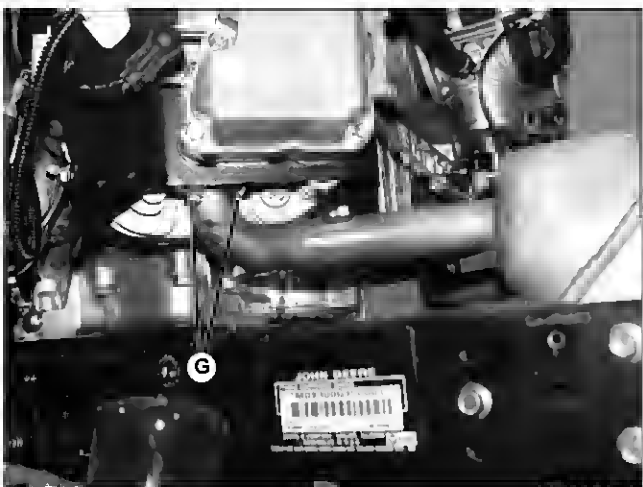
MX44080

5. Remove two screws (D) securing left side heat shield to frame.
6. Remove two screws (E) securing lower heat shield to frame.



MX38251

7. Remove two screws (F) securing muffler mounting bracket to frame.



MX44081

Left side shown, right side is same.

8. Remove flange nuts (G) securing exhaust pipes to engine.

9. Remove muffler and gaskets.

## Installation:

Installation is done in the reverse order of removal.

- Use new gasket for installation.

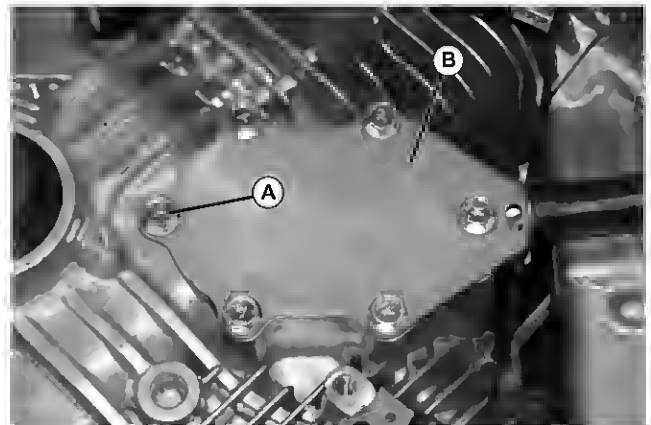
## Specifications:

Flange Nut Torque ..... 22 N•m (16 lb-ft.)

## Breather Inspection

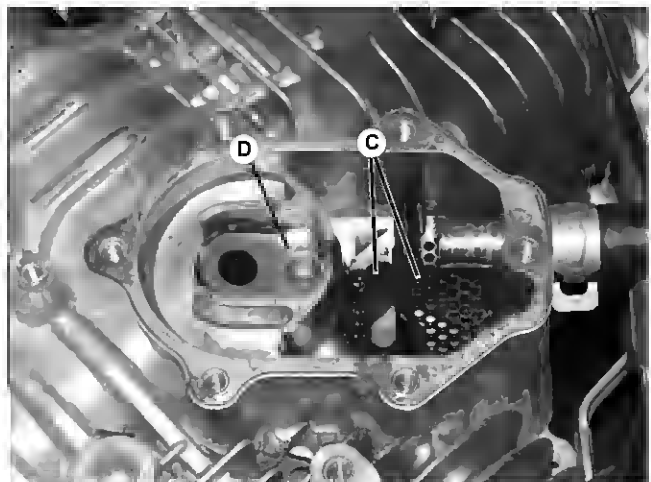
### Procedure:

1. Remove screen and blower housing.
2. Remove flywheel. See "Flywheel Removal and Installation" on page 195.
3. Remove stator.



MX44082

4. Remove six screws (A) securing the breather chamber cover (B) to the crankcase.
5. Remove cover and gasket. Clean area with solvent and allow to dry.



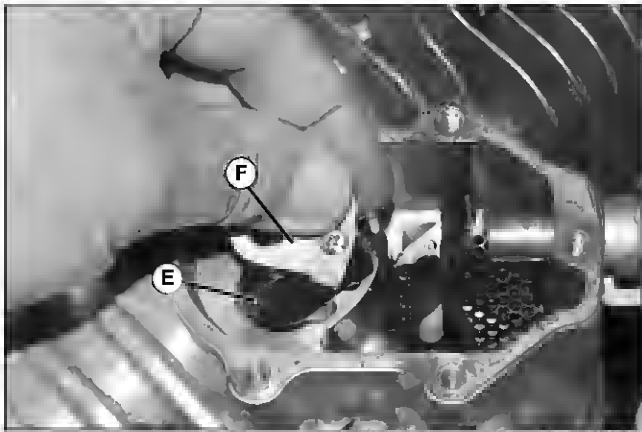
MX44083

6. Check drain holes (C) on breather chamber. Clean out

# ENGINE - KAWASAKI (FS541V) REPAIR

any foreign material that has accumulated before installing breather valve.

7. Remove screw (D).



8. Inspect the breather reed valve (E) and plate (F) for wear, damage, or cracks. Replace as needed.

9. Install a new gasket.

10. Install the breather chamber cover and tighten capscrews to **5.9 N•m (52 lb-in.)**.

11. Install stator.

12. Install flywheel. See "Flywheel Removal and Installation" on page 195.

## Rocker Arm and Push Rod Removal and Installation

### Removal

1. Remove spark plug and rocker arm cover.

**Note:** When piston is at top dead center (TDC), both rocker arms should not have spring tension on them.

2. Turn crankshaft until piston is at TDC of compression stroke for the cylinder being worked on.



3. Remove nut (A). Remove valve clearance adjustment bolt and washer (B) and rocker arm.

**Important: Avoid Damage! Mark push rods for reassembly in original locations.**

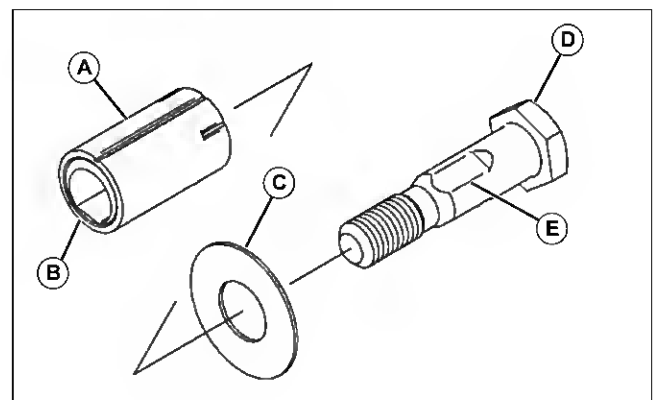
4. Remove the push rods (C) and mark their locations so they are installed in their original locations.

5. Inspect all parts for wear or damage. (See "Rocker Arm and Push Rod Inspection" on page 198.)

### Installation

Installation is done in the reverse order of removal.

**Important: Avoid Damage! Align rocker arms over push rods during assembly.**



- Install collars:
  - Apply engine oil to the collars (A).
  - For No. 1 cylinder, insert collar into rocker arm hole with flattened side (B) facing PTO side.

# ENGINE - KAWASAKI (FS541V) REPAIR

- Insert washers (C) onto the valve clearance adjusting cap screws (D), and install from flywheel side hole of rocker arm.

**Note:** Align the flattened surface of the collars with the flattened surface (E) of the valve clearance adjusting cap screws (D) during installation.

- For No. 2 cylinder, insert collar into rocker arm hole with flattened side (B) facing flywheel side.
- Insert washers (C) onto the valve clearance adjusting cap screws (D), and install from PTO side hole of rocker arm.

**Note:** Apply clean engine oil to contact surfaces of all components prior to installation.

**Important: Avoid Damage! Align rocker arms over push rods during assembly.**

4. Check and adjust valve clearance. See "Valve Clearance Adjustment" on page 182.

- Install rocker covers and tighten rocker cover cap screws to specification.

## Specifications

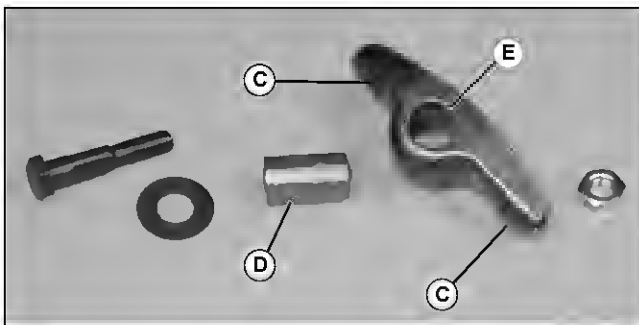
### Valve Adjustment Bolt

Jam Nut Torque ..... 11 N·m (87 lb-in.)

Valve Cover Cap Screw Torque ... 5.9 N·m (52 lb - in.)

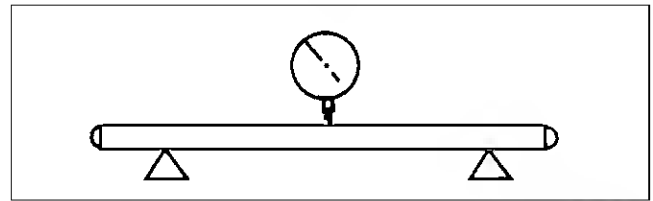
## Rocker Arm and Push Rod Inspection

### Inspection



MX37417

- Inspect all components for wear or damage. Inspect the rocker arm contact points (C) for wear.
- Measure outer diameter of rocker arm pivot collar (D). Replace collar if diameter measures less than specification.
- Measure inner diameter of rocker arm bore (E). Replace rocker arm if inside diameter is greater than specification.



M50044

- Inspect push rod for bend using V-blocks and a dial indicator. Turn rod slowly and read variation on indicator. Replace if variation is greater than specification.

## Specifications

### Rocker Arm Pivot Collar OD Service Limit

(Inlet-Exhaust) ..... 10.91 mm (0.4295 in.)

### Rocker Arm Inside Diameter Service Limit

(Inlet-Exhaust) ..... 11.13 mm (0.4382 in.)

Push Rod Bend (Max) ..... 0.5 mm (0.020 in.)

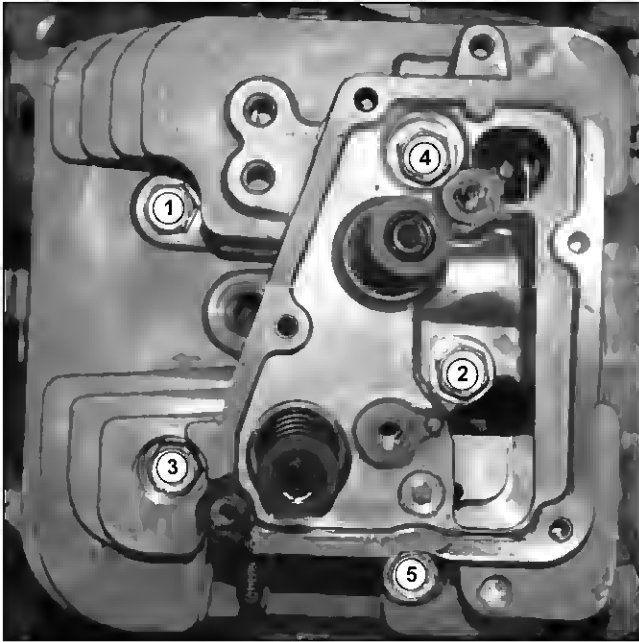
## Cylinder Head Removal

### Removal

1. Remove air cleaner assembly.
2. Remove muffler assembly. (See "Muffler Removal and Installation" on page 195.)
3. Remove carburetor. (See "Carburetor Removal, Disassembly, and Installation" on page 191.)
4. Remove intake manifold. (See "Intake Manifold Removal and Installation" on page 193.)
5. Remove blower housing. (See "Blower Housing Removal and Installation" on page 194.)
6. Remove rocker arm covers.
7. Remove spark plugs.

# ENGINE - KAWASAKI (FS541V) REPAIR

**Important: Avoid Damage! If the removal sequence is not followed, the cylinder head may be warped during removal.**



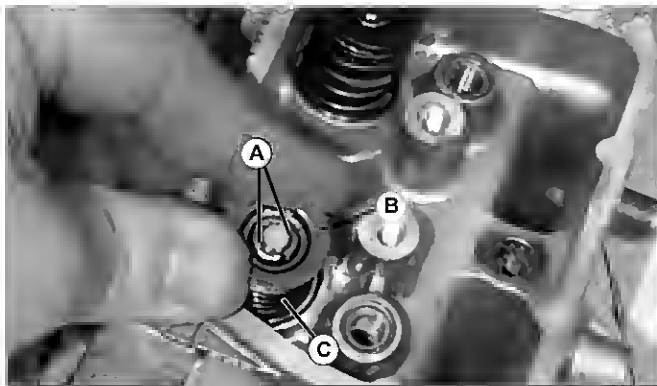
MX43218

8. Turn crankshaft until piston is at TDC of compression stroke for the cylinder being worked on.
9. Loosen the cylinder head bolts 1/4 turn at a time, in sequence (above), to prevent warping the cylinder head during removal.
10. Remove cylinder head assembly.
11. Mark push rods for installation in their original position during assembly.

## Disassemble and Assemble Cylinder Head

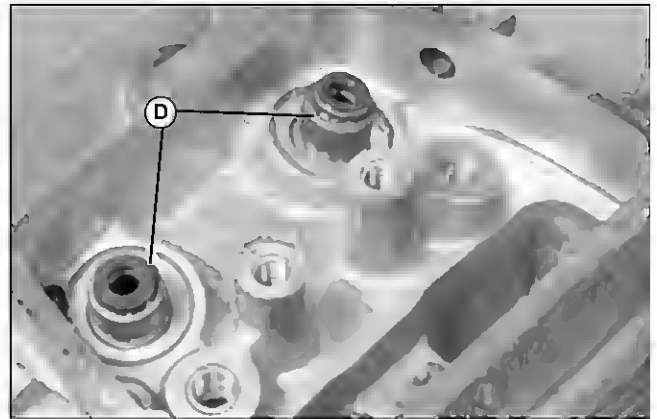
### Disassembly

1. Remove rocker arms. (See "Rocker Arm and Push Rod Removal and Installation" on page 197.)



M95402

2. Compress valve spring and remove colette halves (A).
3. Remove spring retainer (B) and spring (C).



MX36927

4. If necessary to replace stem seal, carefully pry up from bottom (D) with a screwdriver.
5. Inspect springs, valves, guides, and seals. (See "Cylinder Head and Valves Inspection" on page 199.)

### Assembly

Assembly is done in the reverse order of disassembly.

### Specifications

#### Valve Adjustment Screw

Jam Nut Torque ..... 11 N•m (97 lb-in.)

## Cylinder Head and Valves Inspection

### Procedure

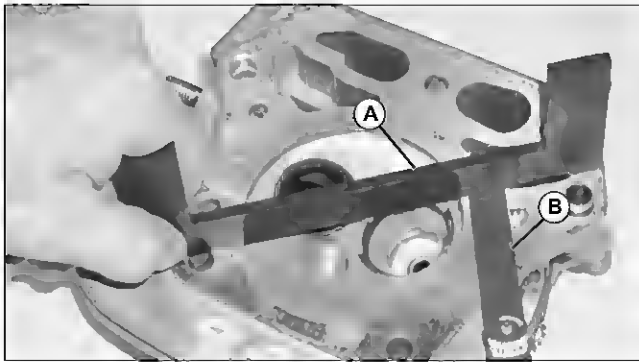
1. Remove cylinder heads. (See "Cylinder Head Removal" on page 198.)
2. Remove carbon deposits from combustion chamber and gasket surface using SCOTCH-BRITE® abrasive pads or an equivalent.



**Caution: Avoid Injury! Reduce compressed air to less than 210 kPa (30 psi) when using for cleaning purposes. Clear area of bystanders, guard against flying chips, and wear personal protection equipment including eye protection.**

3. Clean head with a suitable solvent and dry with compressed air.
4. Inspect for cracks or broken cooling fins.
5. Inspect gasket surface for burrs and nicks.
6. Inspect head gasket for burns and traces of gas leakage. Replace if necessary.
7. Check that oil drainback passages are not plugged.

# ENGINE - KAWASAKI (FS541V) REPAIR



MX6285

8. Put cylinder head on a surface plate or using a straightedge (A) and feeler gauge (B) to check for distortion at several points around the head. Replace head if distortion is greater than specification.

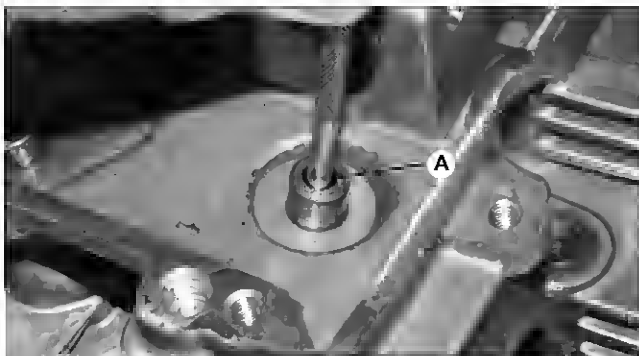
## Specifications

### Cylinder Head Distortion

(Max) ..... 0.05 mm (0.002 in.)

### Valve Guides

**Note:** Intake and exhaust valve guides cannot be replaced; replace head if worn.



MX42565

1. Clean inside of valve guides (A) with valve guide cleaner.
2. Measure inside diameter of valve guides in several places down the length of the guide. Replace cylinder head if inside diameter is greater than specification.

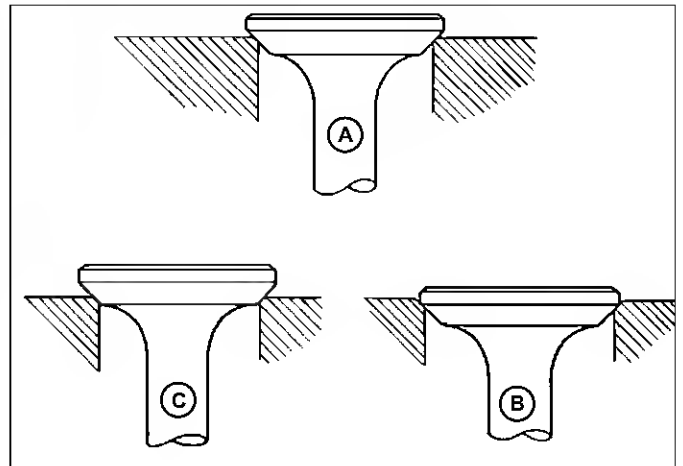
## Specifications

### Valve Guide

(Inside Diameter) (Service Limit). . . 6.08 mm (0.239 in.)

### Valve Seats

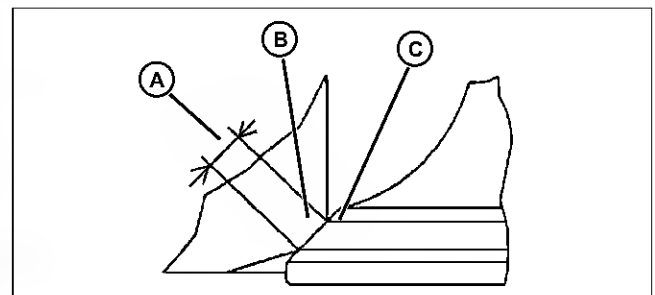
1. If valve seats are loose, warped, or distorted beyond reconditioning, replace cylinder head. Pitted or worn seats can be refaced using a seat cutter.



M18615

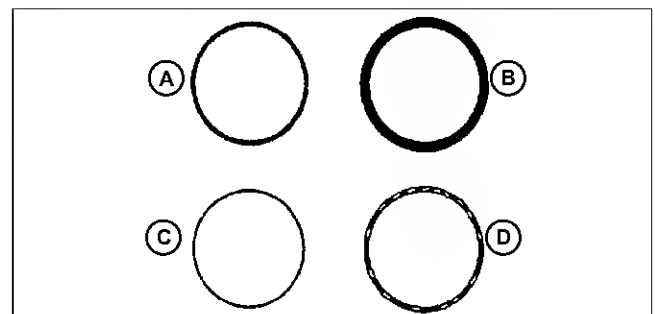
2. Check valve seating pattern for correct width and evenness all around (Note: correct seat position (A), seat too deep (B), and seat too high (C)). If valve seat width is not within specification for intake or exhaust, recondition valve seat.

**Note:** If valve seats are loose, warped, or distorted beyond reconditioning, replace the cylinder head. Pitted or worn seats can be reconditioned using a suitable valve seat cutter.



MX6287

- A- Valve Seat Width
- B- Valve Seat
- C- Valve



MX6288

## Illustration of valve seat patterns.

- A- Correct
- B- Too Wide



# ENGINE - KAWASAKI (FS541V) REPAIR

- C- Too Narrow
- D- Uneven Wear

3. Check valve seating pattern for correct width, correct seat position, and even contact all around. If not within specification, recondition seats and reface or replace valves. (See "Recondition Valve Seats" on page 202.)

- a. Coat the valve seat with machinist's dye.
- b. Install valve and rotate against the seat using a lapping tool.
- c. Remove valve and inspect the contact area.

4. Lap valve after reconditioning with lapping compound and recheck valve seating surface for proper width and evenness of seating pattern. (See "Lap Valves" on page 204.)

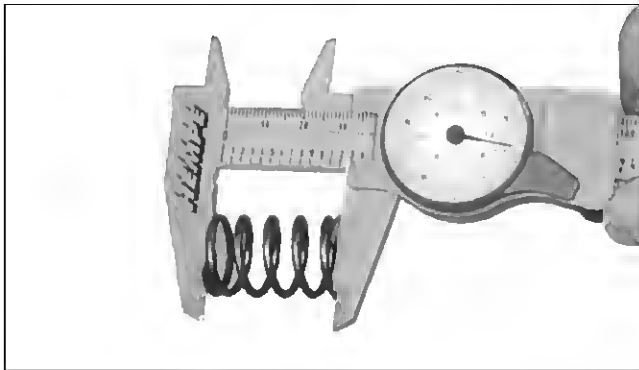
## Specifications:

### Seat Width

Intake	0.8-1.4 mm (0.03-0.05 in.)
Exhaust	1.1-1.6 mm (0.04-0.06 in.)
Valve Guide ID.	6.000-6.012 mm (0.2362-0.2367 in.)
Valve Guide ID (Wear Limit)	6.08 mm (0.239 in.)
Cylinder Head Distortion (Max)	0.05 mm (0.002 in.)
Valve Face Margin (Min)	0.35 mm (0.014 in.)

## Valve Springs

1. Inspect spring for pitting, rust, and burrs. Replace if necessary.



MX6291

2. Measure spring free length. Replace spring if measurement is less than specification.

## Specifications

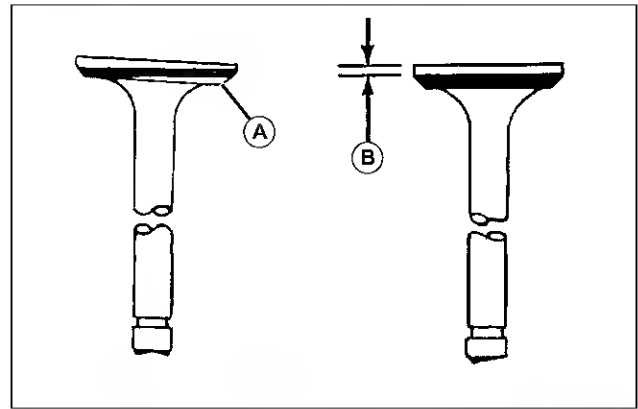
### Valve Spring Free Length

(Service Limit)	31.0 mm (1.22 in.)
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## Intake and Exhaust Valves

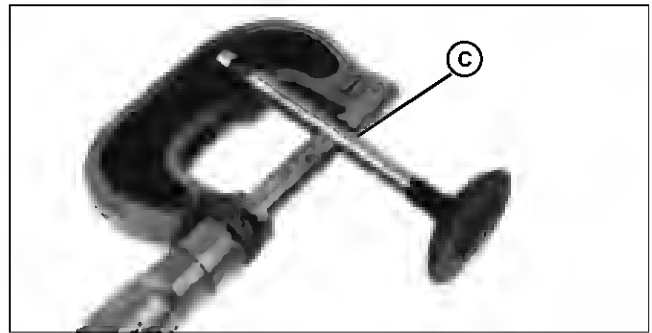
1. Remove carbon from valve head, face, and stem with a power-operated wire brush. Be sure carbon is removed, not merely burnished.

2. Inspect valve head, face, and stems for defects. Replace if necessary.



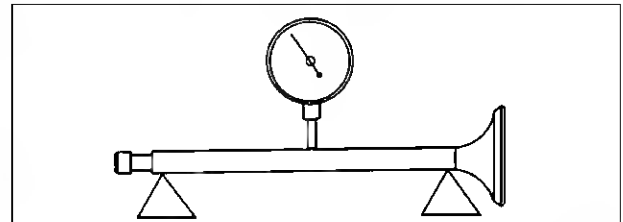
M38087

3. Replace warped valves (A) or valves with margin (B) less than specification.



M53961

4. Measure the diameter of the valve stem (C) in two directions at right angles, at four different positions on the stem. Replace if diameter is less than specification.



M51753

5. Check valve stem for bend using V-blocks and a dial indicator. Turn valve slowly and read variation on indicator. Replace valve if variation is greater than specification.

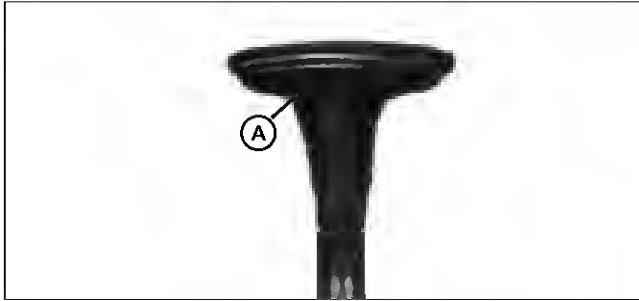
**Important: Avoid Damage! Do not grind the exhaust valve or life will be shortened.**

## Specifications

Valve Margin (Min)	0.35 mm (0.014 in.)
Intake Valve Stem OD (Min)	5.95 mm (0.234 in.)
Exhaust Valve Stem OD (Min)	5.93 mm (0.233 in.)
Valve Stem Bend (Max)	0.05 mm (0.002 in.)

# ENGINE - KAWASAKI (FS541V) REPAIR

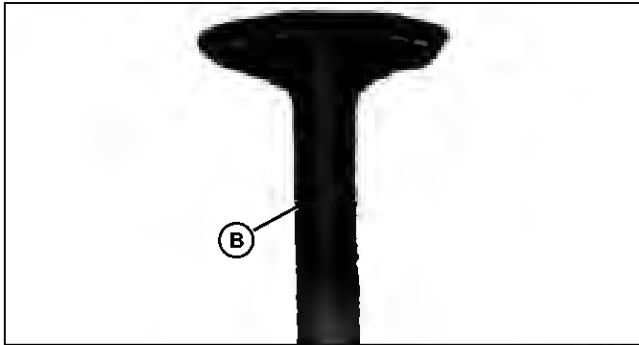
## Analyze Valves



M29934

Lead deposits (A) on the intake valve are caused by exhaust gas leakage past the valve. This indicates that the valve is not seating properly.

Lap the valves after resurfacing the seat to correct this condition.



M5563

Valve stem corrosion (B) is caused by moisture in the engine. Moisture in the fuel/air mixture can condense inside the engine when the engine is stopped and cools down.

Valve corrosion can also occur during storage. Pouring oil in the combustion chamber before storing helps prevent valve corrosion.

Corroded or pitted valves collect deposits and may cause sticking valves. Replace badly corroded or pitted valves.

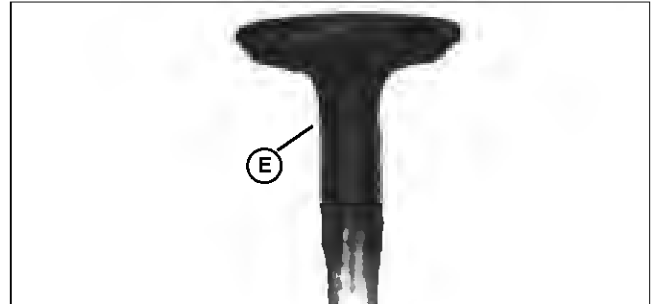


M30024

Exhaust valves are designed to function in temperatures exceeding 2760°C (5000°F). However, when operating at high temperatures for long periods of time, valve burning may occur. Valves running too hot will show a dark discoloration of the valve stem into the area protected by

the valve guide. Another indication is distortion of the valve margin (C) and valve face (D). Valve seat inserts may also begin to burn away.

Other causes for valves running hot are worn valve guides or valve springs, incorrect valve clearance, lean fuel/air mixture, and incorrect or overheated spark plug.



M29936

Using old or stale gasoline is a common cause for sticky valves.

This gummy deposit (E) can be seen on the valve. When this condition exists, the carburetor may also contain gummy deposits and will require cleaning.

Always use fresh gasoline and drain fuel tank, lines, and carburetor before storing machine.

## Recondition Valve Seats

### Other Material

Part No.	Part Name	Part Use
N/A	Machinist's Dye	Check valve seat contact.
N/A	Valve Lapping Compound	Lap valves to seats after reconditioning.

1. Thoroughly clean the combustion chamber and valve seats to remove carbon deposits.

**Note:** *Hardened steel alloy intake and exhaust valve seat inserts are press fitted into the cylinder head. The inserts are not replaceable on the engine but can be reconditioned if not too badly pitted or distorted. If cracked or badly warped, the cylinder head must be replaced.*

2. Inspect valve seats for damage. If seats are loose, warped, or distorted beyond reconditioning, replace cylinder head. Pitted or worn seats can be refaced using a seat cutter.

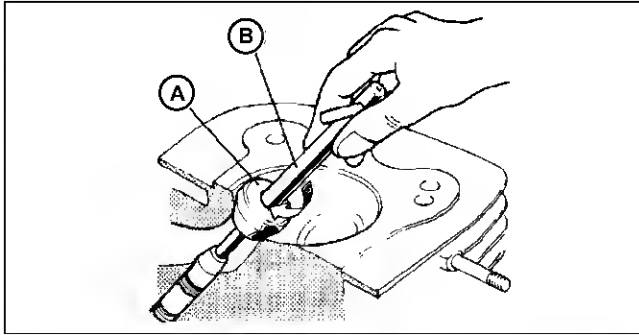
3. Inspect the valve seat contact pattern. (See "Cylinder Head and Valves Inspection" on page 199.)

4. Apply a light coat of machinist's dye to the seat area to improve inspection as the seat is resurfaced.

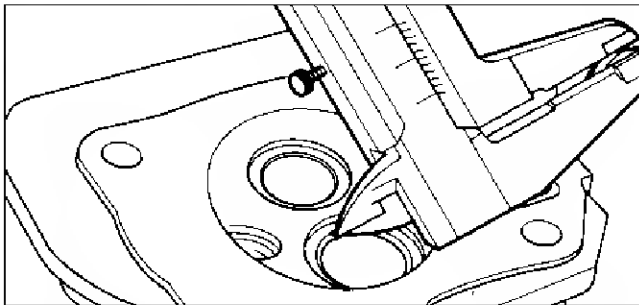
# ENGINE - KAWASAKI (FS541V) REPAIR

**Important: Avoid Damage! ONLY turn cutter clockwise; DO NOT turn counterclockwise. Continue to turn cutter as you lift it off the valve seat.**

**Note: The valve guide must be in good condition to recondition seat properly.**

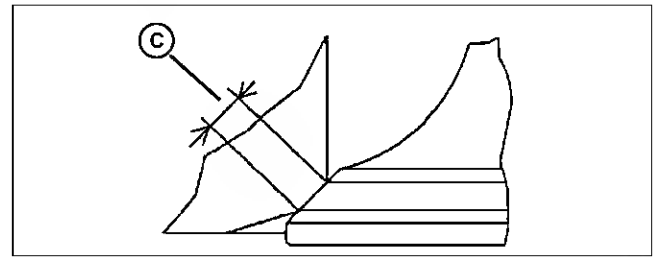


5. Resurface the seat using a 45° cutter (A) and driver (B). Remove only enough material to produce a fresh contact area all around the seat.



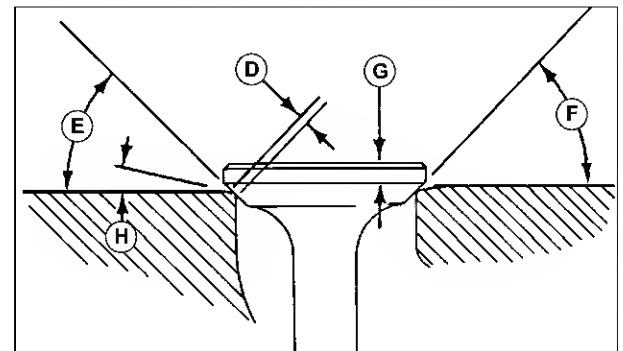
6. Measure seat width.

- Use a 30° cutter to narrow a wide seat to specification.
- Continue to cut with a 45° cutter if the seat is still too narrow.



C- Valve Seat Width

7. Apply a light coating of machinist's dye to the valve seat in the cylinder head. Install the valve and rotate against the seat using a valve lapping tool. Remove the valve and inspect the contact area (C). It must be the correct width and even all the way around.



8. To recondition seat, cut at 45° angle (E) to clean up seat. Cut narrowing angle (H) at 32°. Finish cut at 45° (E) to establish seating surface width (D).

9. Cut valve seating surface (D) as close as possible to specification.

10. Use a 30° cutter to "top dress" and narrow the valve seat, if necessary, so that valve makes contact near the middle of the valve face.

11. Recheck valve seat width and adjust if necessary.

12. Lap valves. (See "Lap Valves" on page 204.)

## Specifications

### Valve Seating Surface

(Standard) Intake . . . . . 0.80-1.40 mm (0.03-0.05 in.)

(Standard) Exhaust . . . . . 1.1-1.6 mm (0.04-0.06 in.)

Valve Seat Angle . . . . . 45°

Valve Face Angle . . . . . 45°

Valve Margin (Min) . . . . . 0.35 mm (0.014 in.)

Valve Narrowing Angle . . . . . 32°

# ENGINE - KAWASAKI (FS541V) REPAIR

## Lap Valves

### Procedure

**Note:** If valve seat does not make proper contact, lap the valve into the seat.



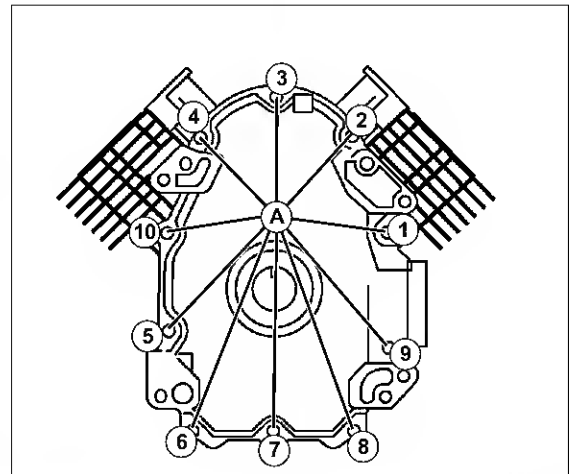
MX36928

1. Apply a small amount of fine lapping compound to face of valve.
2. Grip top of valve with a vacuum cup tool (A) and rotate valve to lap valve to seat.
3. Lift valve from seat every 8 to 10 strokes. Lap until a uniform ring appears around the surface of the valve face.
4. Wash all parts in solvent to remove lapping compound. Dry all parts.
5. Check position of lap mark on valve face. Lap mark must be on or near center of valve face.

## Crankcase Cover Removal and Installation

### Removal

1. Remove engine. (See "Engine Removal and Installation" on page 189.)
2. Remove air cleaner assembly.
3. Remove carburetor and throttle control plate assembly.
4. Remove intake manifold. (See "Intake Manifold Removal and Installation" on page 193.)
5. Remove governor lever arm.
6. Drain crankcase. Capacity (with filter) is approximately 1.7 L (1.8 qt).



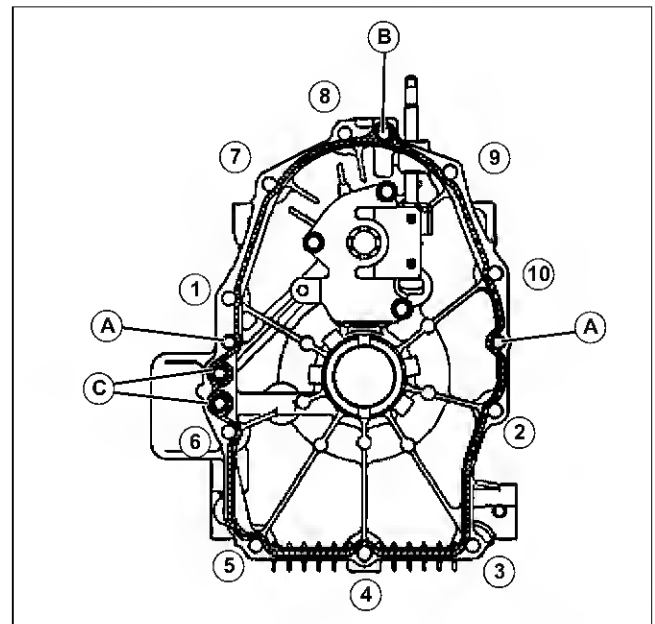
MX24743

7. Loosen and remove the cap screws (A) in the sequence shown.
8. Remove crankcase cover.
9. Clean crankcase and crankcase cover gasket surfaces.

### Installation

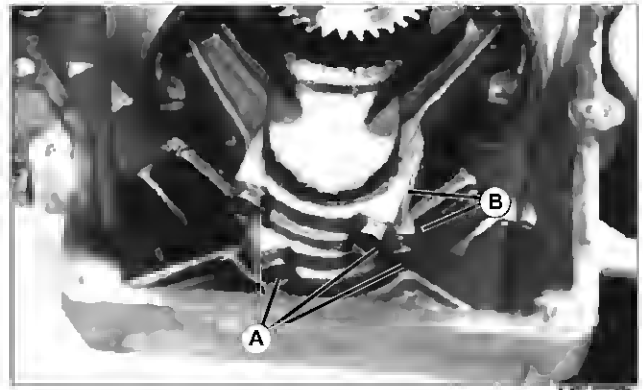
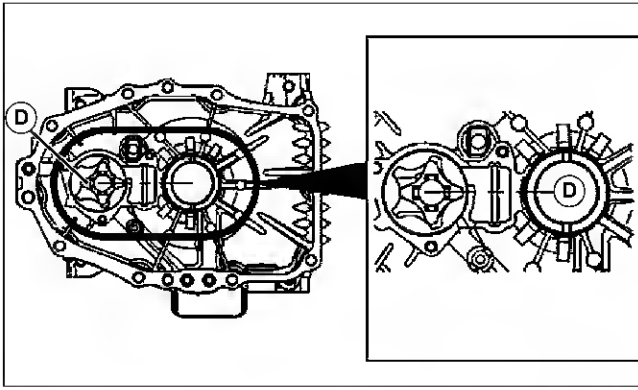
**Important: Avoid Damage!** When installing crankcase cover cap screws, **DO NOT** tighten one cap screw completely before the others or it may cause the crankcase to warp. Turn all cap screws in to a snug position in a uniform manner.

**Note:** Do not force cover. Gears must mesh for proper positioning.



MX42937

# ENGINE - KAWASAKI (FS541V) REPAIR



1. Be sure that the crankcase dowel pins are in holes (A) in the crankcase cover.
2. Install plastic pipe in hole (B).
3. Install plastic pipe in holes (C). Make sure O-rings are installed in two matching holes in engine block.
4. Align one of the slots in the oil pump inner rotor to the center of the crankcase (D).
5. Make sure oil pump drive pin in camshaft is aligned with center of crankshaft before installing crankcase cover.
6. Install the gasket sealant on the crankcase as shown.
7. Install the crankcase cover. If crankcase cover does not easily slide down to crankcase recheck alignment of camshaft and oil pump gear slots. Do not use cover bolts to force cover on. Tighten the cap screws in a two-step process to specification. Use the sequence shown above.

## Torque Specifications

Initial Torque . . . . . 10 N•m (88 lb-in.)  
Final Torque . . . . . 27.4 N•m (20 lb-ft)

## Piston and Connecting Rod

### Removal:

1. Remove cylinder head.
2. Split the crankcase.
3. Remove the camshaft.
4. Turn the crankshaft to expose the connecting rod cap screws.

5. Remove the cap screws (A) and take off the connecting rod caps (B). Note the position of the connecting rod caps for reinstalling the caps.
6. Check cylinder bore for carbon and varnish ridges. These ridges can cause piston damage if not removed.
7. If necessary, remove ridges from top of cylinder bore with a ridge reamer.
8. Push piston and connecting rod into the cylinder and pull out of the cylinder bore.

### Disassembly:

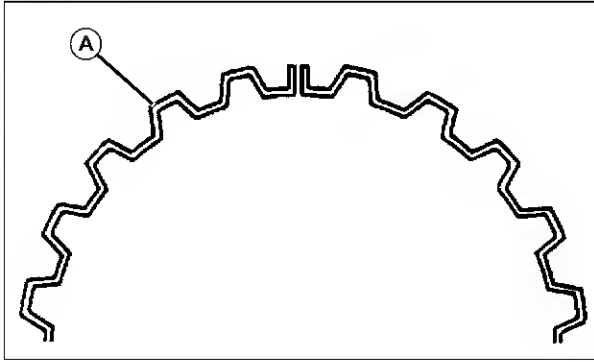
- Analyze piston and piston ring wear.
- Remove piston rings with a piston ring expander.
- Inspect all parts for wear or damage. Replace as necessary.

**Note:** Location of the arrow match mark on the piston head in relation to "K" mark on the connecting rod. Keep parts together as a set.

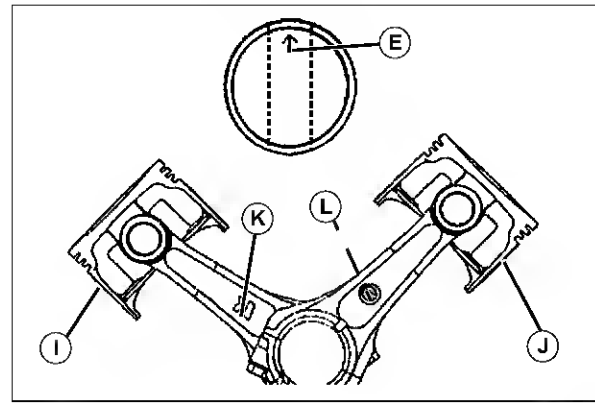
1. Remove one of the piston pin snap rings with a needle nose pliers.
2. Remove the piston pin by pushing it out of the side of the piston that has the ring removed.
3. Using a piston ring pliers, remove the top and second rings.
4. Remove the three piece oil ring.

# ENGINE - KAWASAKI (FS541V) REPAIR

## Assembly:

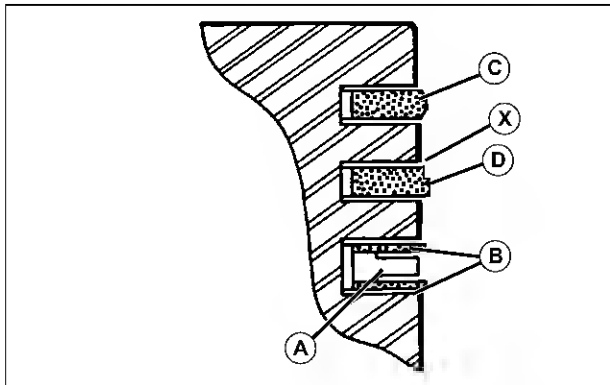


M95389

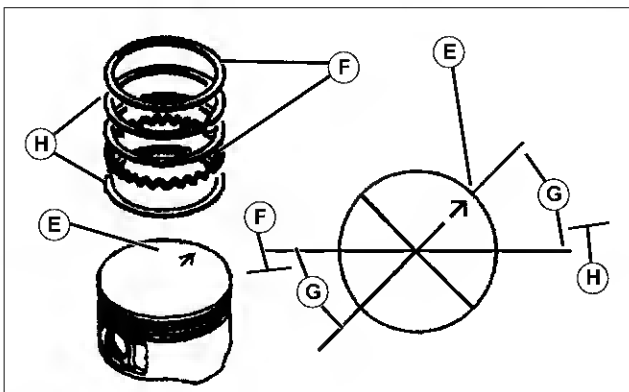


M95392

1. Install the expander (A) in the piston oil ring groove so that the expander ends touch together. Be sure that they do not overlap.
2. Install the upper and lower steel oil rails. The rails are not directional and can be installed either side up.



M38074B



M95393

- A- Expander
- B- Steel Oil Rails
- C- First Compression Ring - Chrome-Plated
- D- Second Compression Ring
- E- Arrow Match Mark
- F- Top Ring End Gap / Upper Steel Rail End Gap
- G- 30° - 45°
- H- Second Ring End Gap / Lower Steel Rail End Gap
- I- No. 1 Cylinder Piston
- J- No. 2 Cylinder Piston
- K- "K" Mark
- L- "K" Mark On Opposite Side

3. Install the second ring with white stripe (X) or notched edge facing up.
4. Install the first compression ring (chrome plated) (C).
5. Align the piston and rings with the piston ring end gap as shown above.
6. Apply a light film of clean engine oil to piston pin and connecting rod bearing during assembly.
7. No. 1 cylinder piston:  
Align the arrow match mark on the piston head with opposite the raised letter "K" mark on the connecting rod.
8. No. 2 cylinder piston:  
Align the arrow match mark on the piston head with the raised letter "K" mark on the connecting rod.
9. Install piston pin and snap ring. Compress snap ring only enough to install the snap ring.
10. Fit a new piston pin snap ring into the side of the piston so that the ring opening of the snap ring does not coincide with the notch in the edge of the piston pin hole.

## Installation:

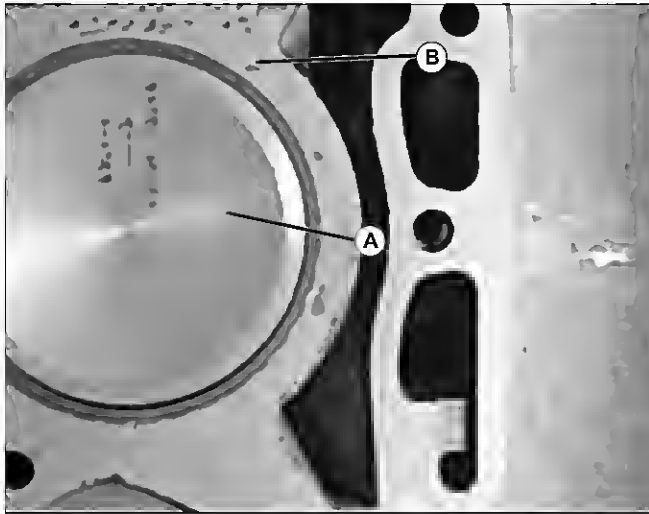
1. Deglaze cylinder bore.
2. Apply a light film of oil to piston and rings. Compress rings with a ring compressor.

# ENGINE - KAWASAKI (FS541V) REPAIR



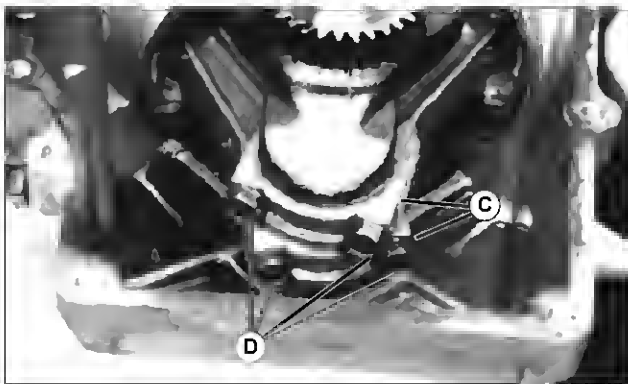
M50074

3. Apply a light film of oil to piston skirt, cylinder bore, connecting rod bearing surface and cap screws.



M95391

4. Install piston assembly in cylinder bore with engraved match mark/arrow (A) on piston head facing flywheel side (B) of engine.



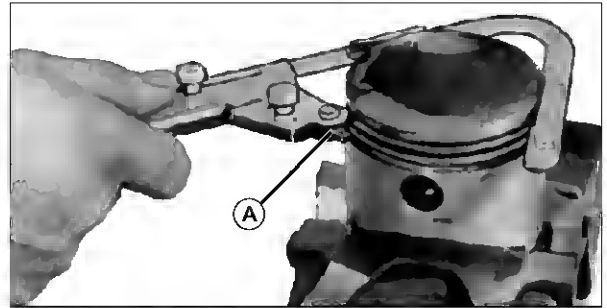
M51726

5. Install connecting rod cap (C) and cap screws (D). Tighten cap screws to **9.8 N•m (87 lb-in.)**.
6. Install crankcase cover and cylinder head.

## Piston Inspection:

**Important: Avoid Damage! Do not use a caustic cleaning solution or a wire brush to clean piston.**

1. Remove all deposits from the piston.



M29946

2. Clean carbon from piston ring grooves with a ring groove cleaner (A). If cleaning tool is not available, break an old ring and use it to carefully clean groove.
3. Check that oil return passages in grooves are open.
4. Inspect piston for scoring or fractures. Replace piston if damaged.

**Note: Inspect ring groove clearance visually. Replace piston if clearance appears excessive.**



M38102

5. Check ring grooves for wear at several points around piston. Replace piston if clearance is greater than specifications.

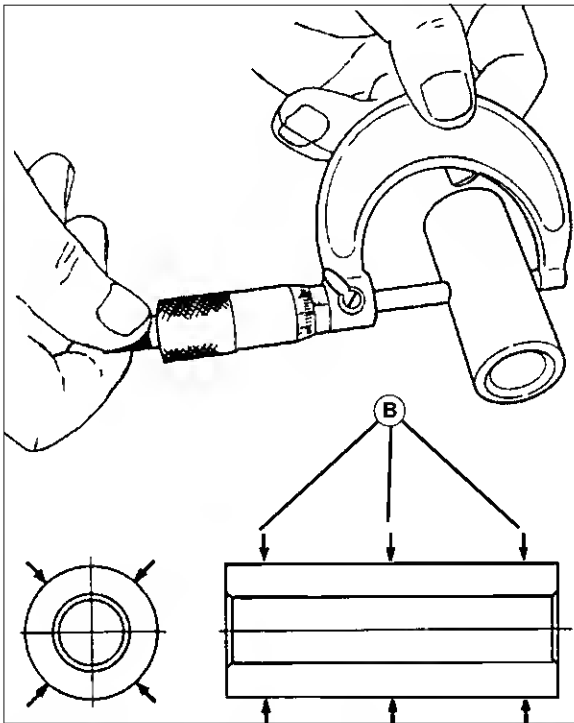
## Ring Groove Side Clearance Specifications:

**1st Compression Ring (Top) . . . . . 0.12 mm (0.005 in.)**

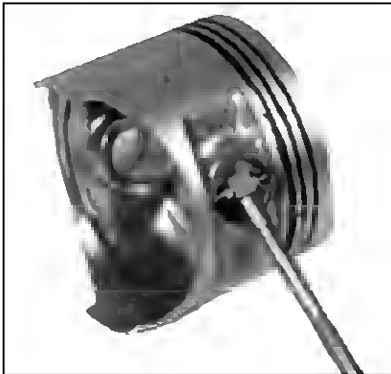
**2nd Compression Ring (Middle) . . . 0.12 mm (0.005 in.)**

6. The oil ring is a three piece assembled ring. It is difficult to measure the ring groove clearance and thickness. Visually inspect only.

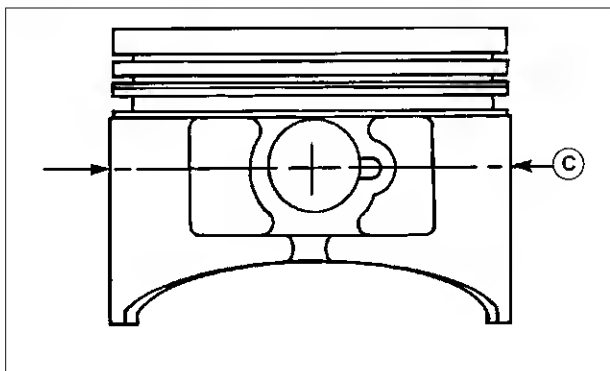
# ENGINE - KAWASAKI (FS541V) REPAIR



7. Measure piston pin diameter at six places (B). Replace pin if measurement is less than **15.96 mm (0.628 in.)**.

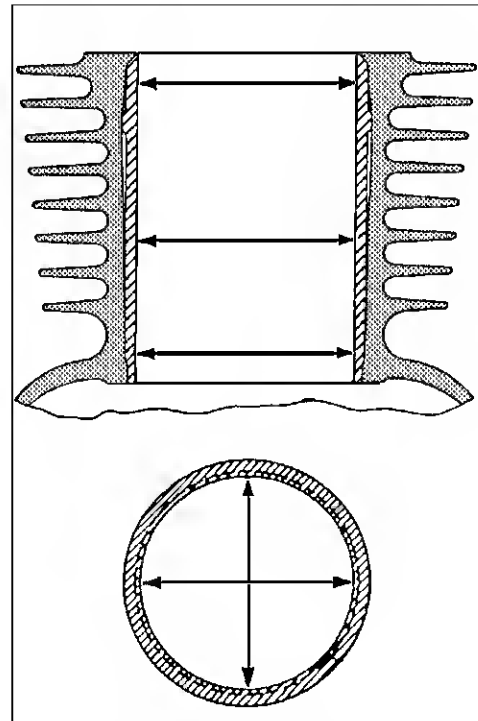


8. Measure piston pin bore. Replace piston if measurement is greater than **16.08 mm (0.633 in.)**.



9. Measure piston OD (C) perpendicular to piston pin bore.

If piston diameter is less than specifications, install a new piston.



10. Measure cylinder bore diameter at three positions; top, middle, and bottom. At these three positions, measure, in both directions; along crankshaft centerline and direction of crankshaft rotation.

**Note: If the engine has had a previous major overhaul, oversize piston and rings may have been installed. Pistons and rings are available in 0.50 mm (0.020 in.) oversize.**

11. If cylinder bore exceeds wear limit, rebore cylinder or replace cylinder block. See "Resize Cylinder Bore" on page 212.

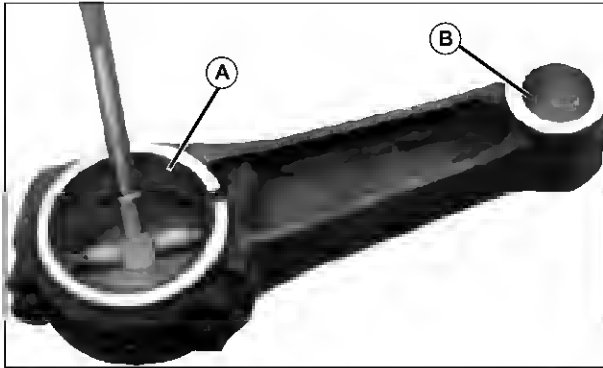
**Note: If cylinder is rebored, oversize piston and rings must be installed.**

## Connecting Rod:

1. Analyze crankshaft and connecting rod wear.
2. Clean and inspect rod. Replace if scored.
3. Install connecting rod cap. Tighten to **9.8 N•m (87 lb-in.)**.



# ENGINE - KAWASAKI (FS541V) REPAIR



4. Measure connecting rod crankshaft bearing diameter (A) and piston pin diameter (B). Replace connecting rod if either measurement is greater than specifications.

## Piston Rings:

1. Measure thickness of top and second piston rings at several places. If thickness is less than **1.1 mm (0.043 in.)**, replace piston ring.



2. Check piston ring end gap. Install each ring squarely in bore approximately **25.4 mm (1.0 in.)** down from top of cylinder.

3. Check end gap. Replace if end gap is greater than specifications.

## Ring Groove Side Clearance Specifications:

**1st Compression Ring** ..... 0.12 mm (0.005 in.)  
**2nd Compression Ring** ..... 0.12 mm (0.005 in.)

## Piston OD Specifications:

**Standard Piston** ..... 72.79 mm (2.866 in.)  
**Oversized Piston** ..... 73.29 mm (2.88 in.)

## Cylinder Bore ID:

**Standard Bore** ..... 72.98 - 73.00 mm (2.873 - 2.874 in.)  
**Oversized Bore** ..... 73.48 - 73.50 mm (2.893 - 2.894 in.)

**Bore Out of Round** ..... 0.01 mm (0.0004 in.)  
**Bore Out of Round Limit** ..... 0.05 mm (0.002 in.)

## Connecting Rod Bearing ID (Wear Limit):

**Crankshaft Bearing** ..... 38.04 mm (1.5 in.)  
**Piston Pin Bearing** ..... 16.05 mm (0.632 in.)

## End Gap Specifications:

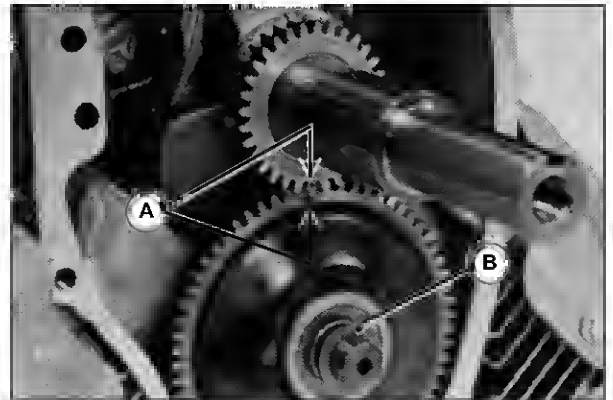
**Top Ring** ..... 0.70 mm (0.028 in.)  
**Second Ring** ..... 0.9 mm (0.035 in.)  
**Oil Control Ring** ..... 1.05 mm (0.041 in.)

## Camshaft and Tappets

### Removal and Installation:

1. Remove fuel pump.
2. Remove rocker arm assemblies.
3. Remove crankcase cover.

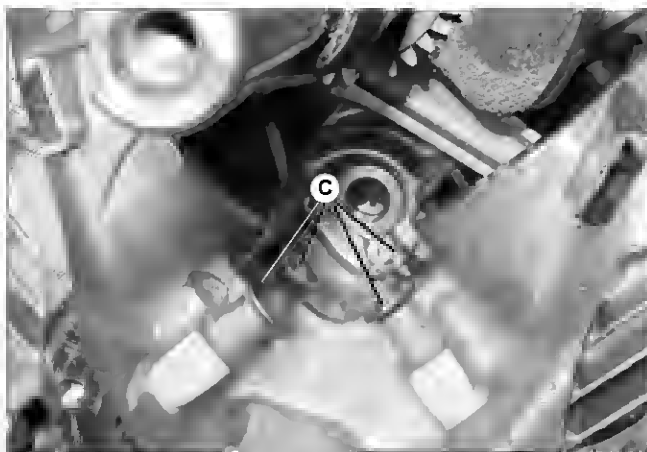
**Important: Avoid Damage! Align timing marks to prevent damage to tappets when removing camshaft.**



4. Rotate crankshaft until timing marks (A) align.
5. Remove and inspect camshaft (B).

**Note: Mark tappets so they can be installed in their original guides during assembly.**

# ENGINE - KAWASAKI (FS541V) REPAIR



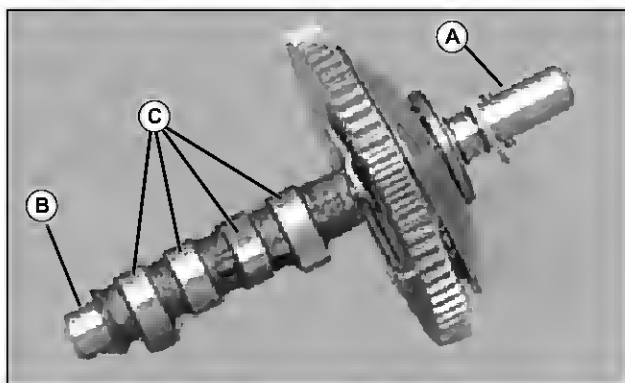
6. Remove and inspect tappets (C) for wear or damage. Replace if necessary.

**Installation is done in the reverse order of removal.**

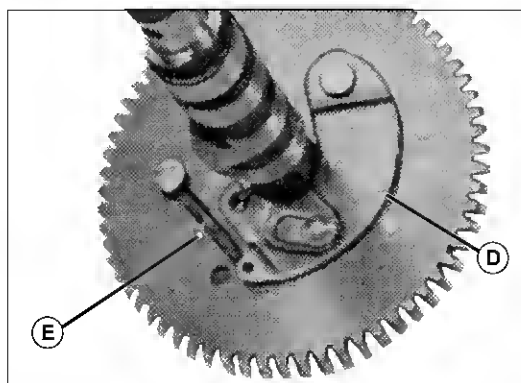
- Align timing marks when installing camshaft.

## Inspection:

1. Inspect camshaft for worn or broken teeth.



2. Measure PTO side journal (A), flywheel side journal (B) and lobes (C). Replace camshaft and tappets if any measurement is less than specifications.



3. Inspect Automatic Compression Release weight (D) for

damage.

4. Inspect spring (E). Replace if worn or damaged.
5. Shake the camshaft assembly and check that the ACR weight (D) swings smoothly.



**Picture Note: Cylinder Block Bearing**



**Picture Note: Crankcase Cover Bearing Under Oil Pump**

6. Measure camshaft bearings in cylinder block and crankcase cover. Replace block or cover if either diameter is greater than **16.14 mm (0.635 in.)**.

## Camshaft Specifications (Minimum):

Side Journals ..... 15.99 mm (0.630 in.)  
Cam Lobe Height ..... 29.62 mm (1.166 in.)

## Crankshaft and Main Bearings

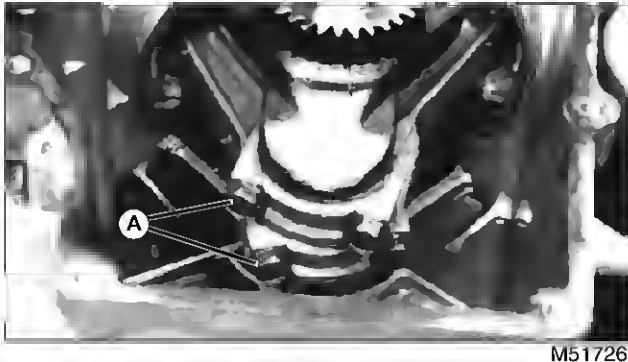
### Removal and Installation:

1. Remove flywheel and crankcase cover.
2. Remove camshaft.

# ENGINE - KAWASAKI (FS541V) REPAIR

**Important: Avoid Damage! Connecting rod caps must be installed on the same connecting rods they were removed from.**

3. Mark connecting rod caps to aid in installation.



4. Remove connecting rod caps (A) and push pistons to top of cylinder.
5. Remove crankshaft.
6. Inspect crankshaft for wear or damage.

**Installation is done in the reverse order of removal.**

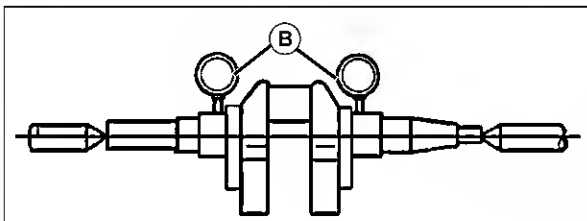
- Cover keyway on flywheel end of crankshaft with tape to prevent seal damage when installing crankshaft.
- Apply a light film of clean engine oil on crankshaft bearing surfaces before installation.
- Pack oil seals with lithium base grease.
- Install connecting rod caps and tighten to **9.8 N•m (87 lb-in.)**.

## Inspection:

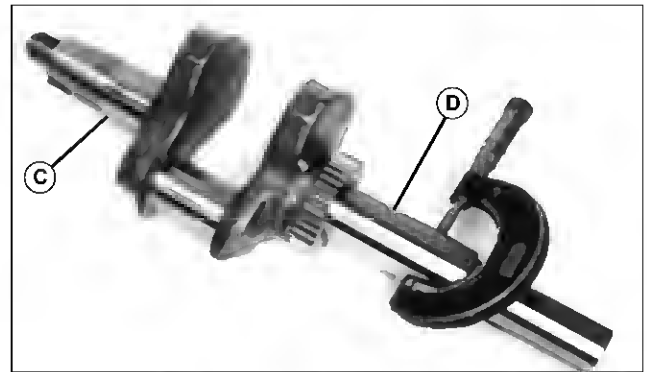
1. Analyze crankshaft and connecting rod wear.

**Important: Avoid Damage! A bent crankshaft must be replaced; it cannot be straightened.**

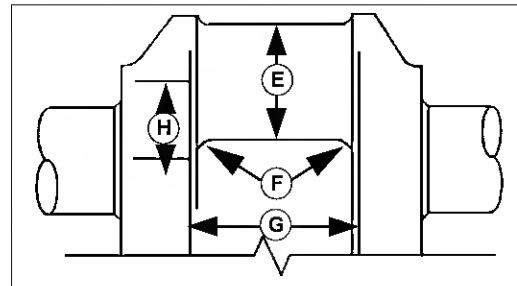
2. Clean and inspect crankshaft. Replace if scratched or damaged.



3. Place crankshaft into an alignment jig and slowly rotate crankshaft. Use dial indicators (B) to measure maximum Total Indicated Runout (TIR). If runout exceeds **0.05 mm (0.002 in.)**, replace crankshaft.



4. Measure main bearing journal diameters. If PTO side journal (D) OD is less than **37.90 mm (1.492 in.)** replace crankshaft. If flywheel side journal (C) OD is less than **34.90 mm (1.374 in.)** replace crankshaft.



5. Measure connecting rod journal diameter (E) and inspect journal radii (F) for cracks. Connecting rod journal can be resized to accept undersized rod. Have grinding done by a reliable repair shop.

If undersized journal diameter is less than specifications, replace crankshaft.



6. Measure crankshaft main bearing diameter in crankcase and crankcase cover. Replace crankcase cover if diameter is greater than **38.10mm (1.5 in.)**. Replace crankcase if crankshaft bearing diameter is greater than **35.10 mm (1.382 in.)**.

## Connecting Rod Journal OD (Wear Limit):

Standard ..... **37.94 mm (1.49 in.)**

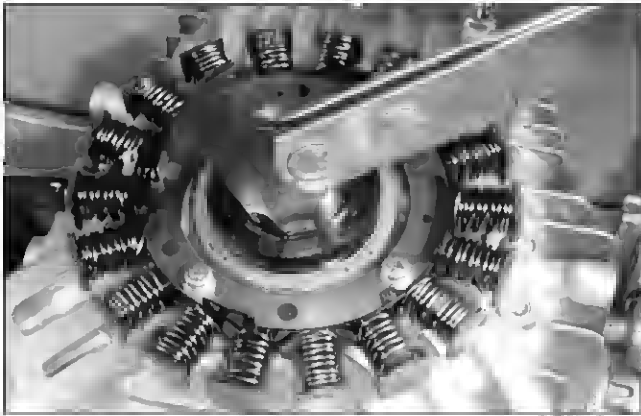
# ENGINE - KAWASAKI (FS541V) REPAIR

## Crankshaft Oil Seal Replacement

**Note:** Oil seals can be replaced with crankshaft installed. Make sure oil seal removal tool does not contact crankshaft. If engine is disassembled, simply pry out seals with a large screwdriver and install new ones with a seal driver.

### Replacement (Flywheel End)

1. Remove blower housing, fan, and flywheel.



2. Using care not to contact crankshaft or coils on stator, pry seal out of bore.
3. Apply lithium based grease inside lips of new seal. Install seal with lip toward inside of engine. Using a seal driver, install seal flush with top of bore.

### Replacement (PTO End)

1. Remove clutch and sheave assemblies.
2. Remove engine from machine. (See "Engine Removal and Installation" on page 189.)



3. Using care not to contact crankshaft, pry seal out of crankcase cover.
4. Apply lithium based grease inside lips of new seal.
5. Install seal with lip toward inside of engine using a seal driver. Press in seals until flush with flange surface.

## Deglaze Cylinder Bore

1. Deglaze cylinder bore using a rigid hone with a 220 to 300 grit stone.
2. Use hone as instructed by manufacturer to obtain 45° crosshatch pattern.

**Important: Avoid Damage! Do not use gasoline, kerosene, or commercial solvent to clean cylinder bores. Solvents will not remove all abrasives from cylinder walls.**

3. Clean cylinder walls using clean white rags and warm soapy water. Continue to clean cylinder until white rags show no discoloration.

## Resize Cylinder Bore

**Important: Avoid Damage! Check stone for wear or damage. Use correct stone for the job.**

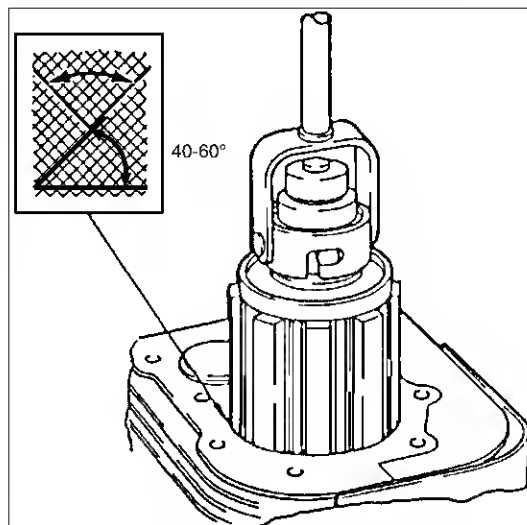
The cylinder block can be resized to use **0.50 mm (0.020 in.)** oversize pistons and rings. Have a reliable repair shop resize the block, or use the drill press and honing tool. Resize cylinder with a honing tool to initial and final bore specifications.

### Procedure:

1. Align center of bore to drill press center.
2. Lower and raise hone until ends extend **20 - 25 mm (0.75 - 1.0 in.)** past ends of cylinder.
3. Adjust hone so lower end is even with end of cylinder bore.
4. Adjust rigid hone stones until they contact narrowest point of cylinder.
5. Coat inside of cylinder with honing oil. Turn hone by hand. Adjust if too tight.
6. Run drill press between 200 - 250 rpm. Move hone up and down in cylinder approximately 20 times per minute.

**Note: Measure bore when cylinder is cool.**

# ENGINE - KAWASAKI (FS541V) REPAIR



M82412A

7. Stop press and check cylinder diameter.

**Note:** Finish should not be smooth, but have a 40 - 60° cross-hatch pattern.

8. Check bore for size, taper, and out-of-round.

9. Hone the cylinder an additional **0.006 - 0.008 mm (0.0002 - 0.0003 in.)** for final bore specifications. This allows for shrinkage when cylinder cools.

**Important: Avoid Damage! DO NOT use gasoline or commercial solvents to clean cylinder bores. Solvents will not remove metal particles produced during honing.**

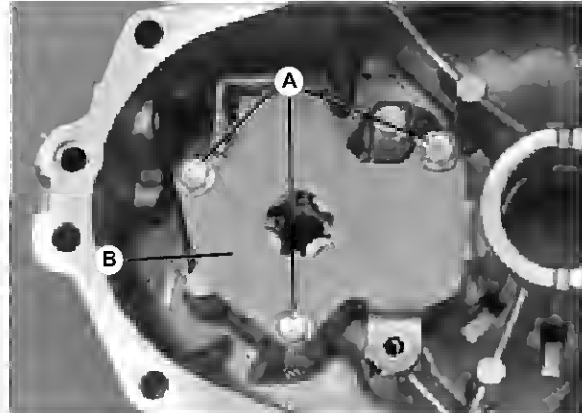
10. Clean the cylinder thoroughly using soap, warm water and clean rags. Continue to clean cylinder until white rags show no discoloration.

11. Dry the cylinder. Apply engine oil to cylinder wall.

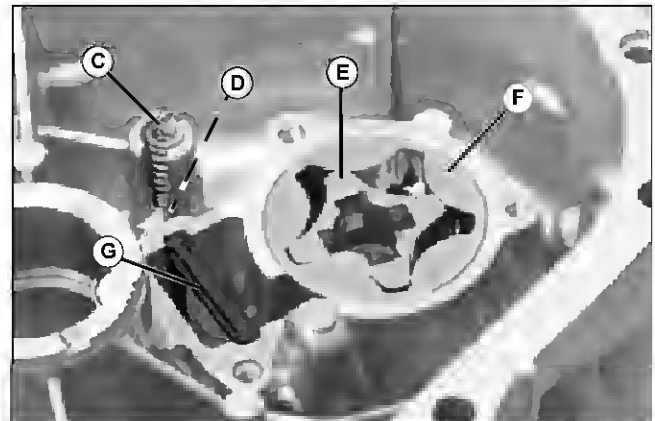
## Oil Pump Removal, Inspection and Installation

### Disassembly and Assembly:

1. Remove crankcase cover. See "Crankcase Cover Removal and Installation" on page 204.



2. Remove the three mounting cap screws (A) and remove the cover plate (B) out of the crankcase.



3. Remove relief valve spring (C) and ball (D).

4. Remove the inner (E) and outer (F) rotors.

5. Remove strainer screen (G).

6. Inspect all parts for wear or damage.

**Assembly is done in the reverse order of disassembly.**

- Fill rotor housing with engine oil for initial lubrication.
- Install the outer (F) and inner (E) rotors.
- Install relief valve ball (D) and spring (E).
- Install oil pump cover plate (B), and secure with three cap screws (A).
- Tighten the three cap screws (A) to **5.9 N•m (52 lb-in.)**.

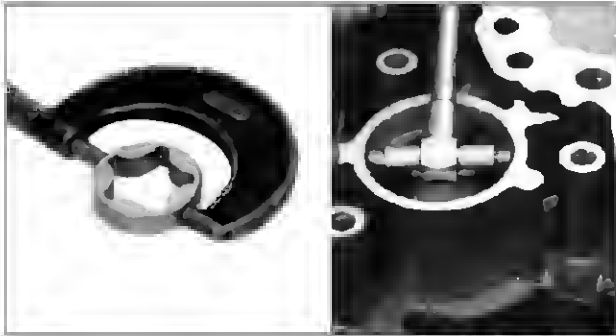
# ENGINE - KAWASAKI (FS541V) REPAIR

## Inspection:

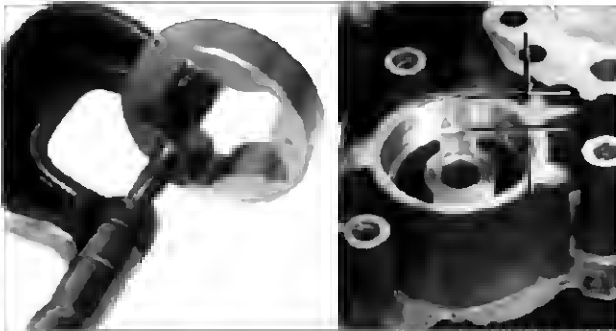
1. Inspect all parts for wear or damage. Replace as necessary.



2. Measure rotor shaft diameter. If shaft OD is less than **10.92 mm (0.430 in.)**, replace shaft.
3. Measure rotor shaft bearing. If bearing ID is greater than **11.07 mm (0.436 in.)**, replace crankcase cover.



4. Measure outside diameter of outer rotor. If OD is less than **52.31 mm (2.059 in.)**, replace outer rotor.
5. Measure inside diameter of rotor housing. If ID is greater than **52.72 mm (2.076 in.)**, replace crankcase cover.



6. Measure thickness of outer rotor. If thickness is less than **14.91 mm (0.587 in.)**, replace rotor.
7. Measure outer rotor housing depth. If depth is greater

than **15.16 mm (0.596 in.)**, replace crankcase cover.



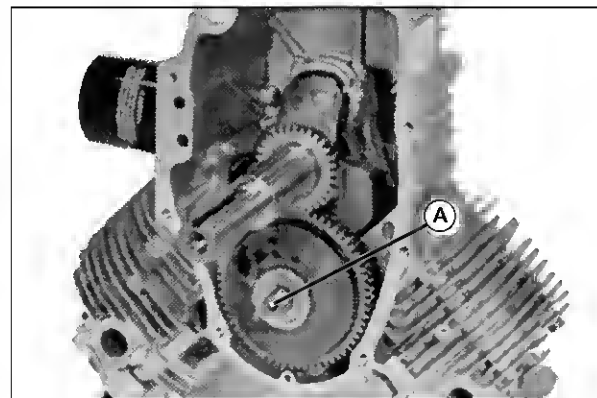
8. Measure inner to outer rotor clearance (G). If clearance is greater than **0.2 mm (0.008 in.)**, replace both rotors.



9. Measure relief valve spring. If free length is less than **20.4 mm (0.803 in.)**, replace spring.

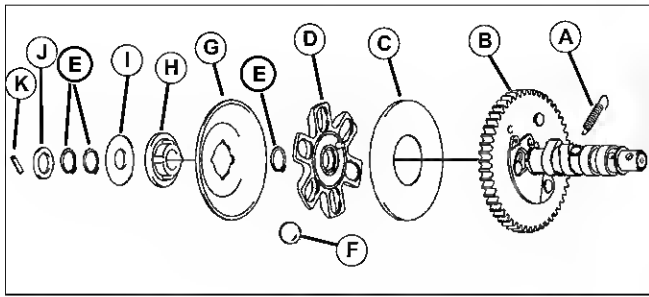
## Governor Removal, Inspection, and Replacement

1. Remove crankcase cover. See "Crankcase Cover Removal and Installation" on page 204.
2. Remove rocker covers and push rods.



3. Turn engine upside down and remove camshaft (A).

# ENGINE - KAWASAKI (FS541V) REPAIR



M95423A

- A- Automatic Compression Release Spring
- B- Camshaft
- C- Governor Plate
- D- Ball Guide
- E- Snap Ring (3)
- F- Steel Balls (6 used)
- G- Ball Plate
- H- Sleeve
- I- Washer
- J- Washer
- K- Pin

4. Disassemble the governor assembly from the camshaft.
5. Inspect governor for wear or damage. Replace if necessary.
6. When assembling, be sure the steel balls are seated in slots on the ball guide and that the snap rings are fully seated in their grooves.

## Governor Shaft Inspection and Replacement

**Note:** It is not necessary to remove governor shaft unless damaged.

1. Remove crankcase cover. See "Crankcase Cover Removal and Installation" on page 204.
2. Unscrew the governor shaft plate screws and pull the governor shaft out of the crankcase cover.
3. Replace the oil seal if the lip shows signs of leakage or it has been damaged.
4. Inspect governor shaft (A) for wear or damage. Replace if necessary.

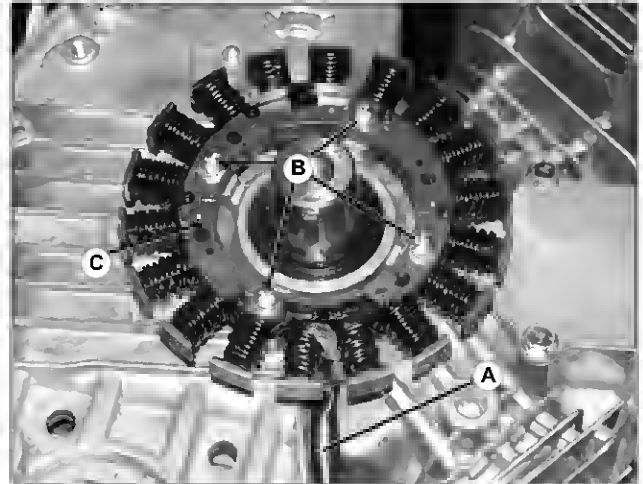
**Installation is done in the reverse order of removal.**

- Apply clean engine oil to the governor shaft.
- Insert the governor shaft into the crankcase.
- Install the governor shaft plate to the shaft and tighten the screws to **2 N•m (17 lb-in.)**.
- Check that governor shaft turns freely within its operating range.
- If oil seal has been removed, press a new seal into

crankcase with the seal lip to the inside.

- Press the seal in to flush to **1.0 mm (0.04 in.)** below crankcase surface.

## Stator Removal and Installation



MX44075

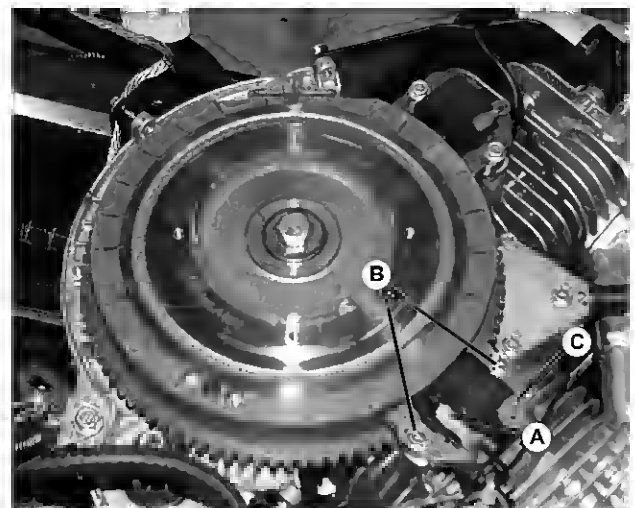
1. Remove flywheel.
2. Disconnect stator lead (A) from regulator/rectifier on side of engine.
3. Remove screws (B) and stator (C).

### Installation:

Installation is done in the reverse order of removal.

## Ignition Coil Removal and Installation

1. Remove blower housing.



MX44076

2. Disconnect wiring lead (A).
3. Remove cap screws (B) and armature with coil (C).

# ENGINE - KAWASAKI (FS541V) REPAIR

Installation is done in the reverse order of removal.

- Adjust ignition coil air gap. See "Ignition Coil Air Gap Adjustment" on page 188

## Starting Motor

### Analyze Condition:

The starting motor overheats because of:

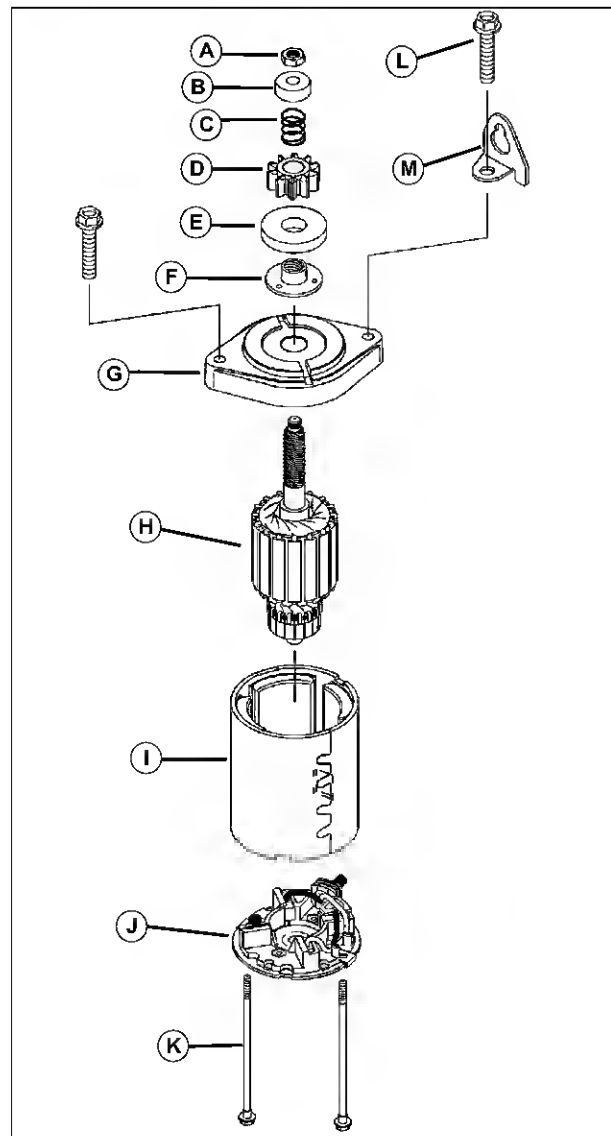
- Long cranking.
- Armature binding.

The starting motor operates poorly because of:

- Armature binding.
- Dirty or damaged starting motor drive.
- Badly worn brushes or weak brush springs.
- Excessive voltage drop in cranking system.
- Battery or wiring defective.
- Shorts, opens, or grounds in armature.

**Note:** *Fields in starting motor are permanent magnets and are not serviceable. If housing or magnets are damaged, replace starting motor.*

### Starter Motor Component Location



MX44090

- A- Nut
- B- Washer
- C- Spring
- D- Pinion
- E- Seal
- F- Nut
- G- Cover
- H- Armature
- I- Housing With Magnets
- J- Brush Holder Assembly
- K- Thru Bolt
- L- Bolt (2)
- M- Engine Lift Bracket



# ENGINE - KAWASAKI (FS541V) REPAIR

## Required Tools:

- JDG1087 C-Ring Remover
- JDG1086 C-Ring Installer

## Disassembly and Assembly:

1. Mark body and covers for correct alignment during reassembly.
2. Remove shaft cover and use a C-Ring removal tool, JDG1087 to remove the C-Ring.
3. Remove retainer (C), spring (D), pinion (E) and bushing (F).
4. Remove thru bolts (J), and cover (L) from housing (M).
5. Hold the armature (I) and the brush end cap assembly (L) against a work surface while sliding the Housing off the armature.
6. Inspect parts for wear or damage.
7. Test starting motor armature and brushes. See Inspection and Test procedures.

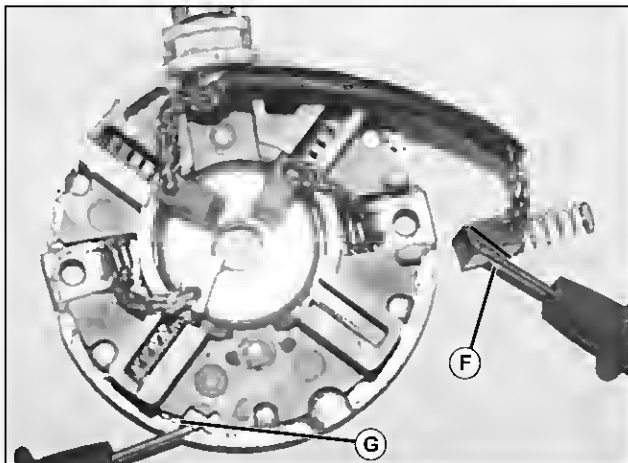
## Assembly is done in the reverse order of disassembly.

Apply a lithium based lubricant sparingly to:

- Armature shaft splines.
- Points where shaft contacts cover.

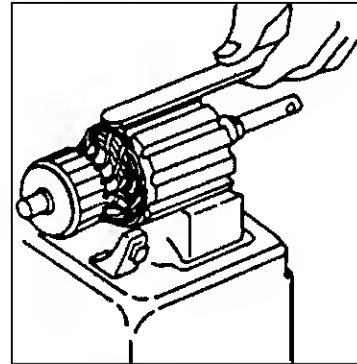
## Inspection and Test:

1. Measure field coil brush lengths. If any one brush length is less than **10.5 mm (0.413 in.)**, replace all four brushes.
2. Inspect brush springs for wear or damage. Replace if necessary.



3. Test for brush continuity. Touch one probe of tester to field coil brush (F) and the other probe to the end cap housing (G). Be sure the brush lead is not touching the housing. If there is not continuity, the brush assembly must be replaced.

**Important: Avoid Damage! Do not clean armature with solvent. Solvent can damage insulation on windings. Use only mineral spirits and a brush.**



4. Locate short circuits by rotating armature on a growler while holding a hacksaw blade or steel strip on armature. The hacksaw blade will vibrate in area of short circuit.

**Note: Shorts between bars are sometimes caused by dirt or copper between bars. Inspect for this condition.**

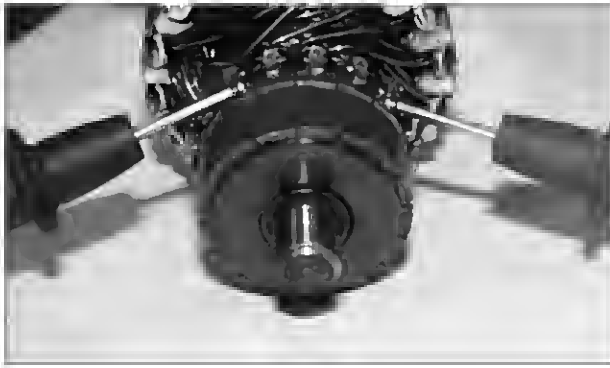
5. If test indicates short circuited windings, clean the commutator of dust and fillings. Check armature again. If test still indicates short circuit, replace armature.



6. Test for grounded windings using an ohmmeter. Touch probes on each commutator bar. Armature windings are connected in parallel, so each commutator bar needs to be checked. If test shows continuity, a winding is grounded and the armature must be replaced.

## ENGINE - KAWASAKI (FS541V) REPAIR

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MX14444

7. Test for open circuited windings using an ohmmeter. Touch probes on each commutator bar. If test shows no continuity, there is an open circuit and armature must be replaced.

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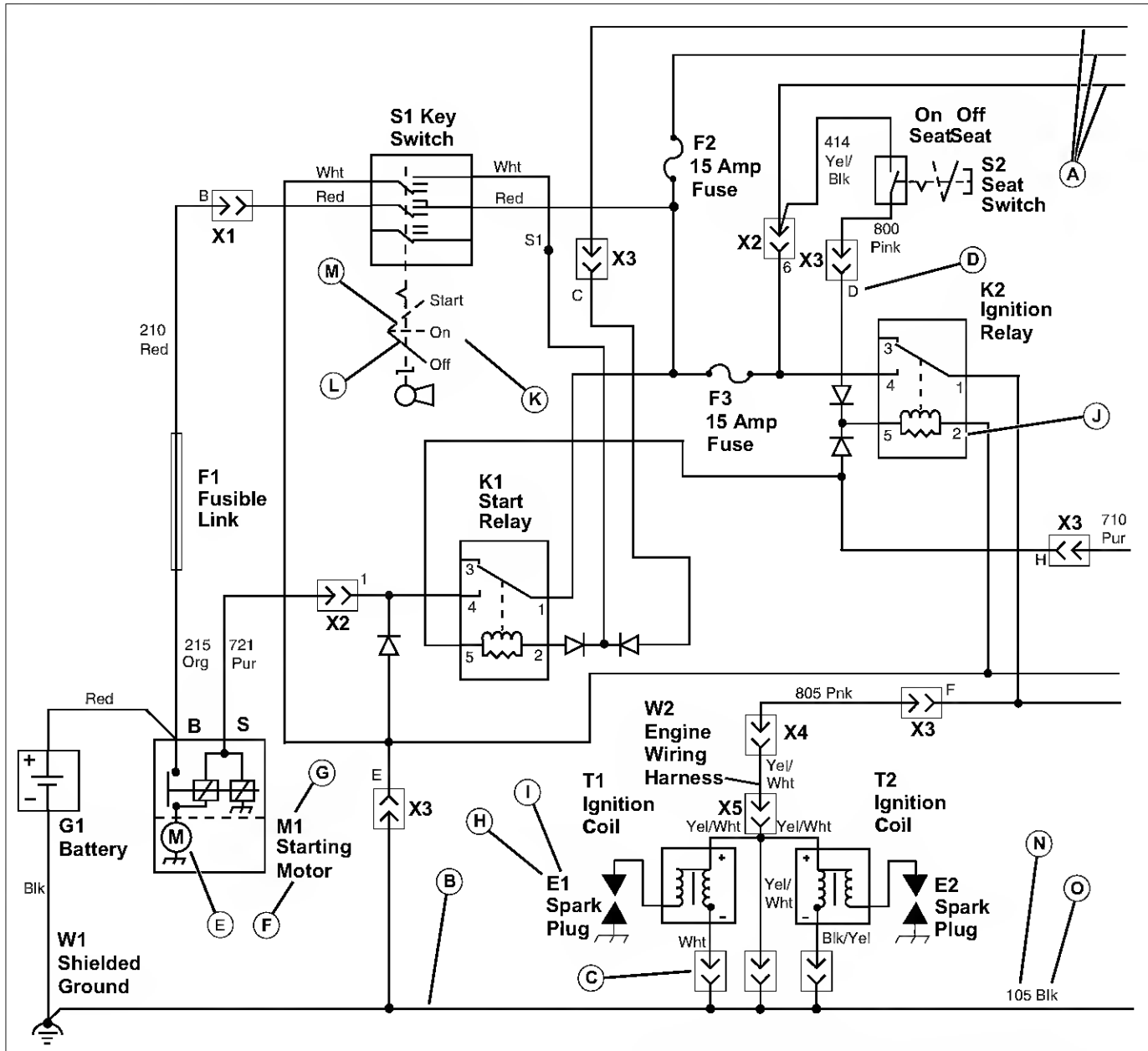
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# ELECTRICAL INFORMATION

## Information

## Reading Electrical Schematics



mif

The schematic is made up of individual circuits laid out in a sequence of related functions. It is formatted with all power wires (A) across the top and all ground wires (B) across the bottom. Current flow is generally from top to bottom through each circuit and component. All components are shown in the off position. The diagram does not list connector (C) information unless needed to avoid confusion. If the connector is shown, the number next to it is the terminal pin location (D) in the connector.

Each component is shown by a symbol (E), its name (F), and an identification code (G). The identification code contains a device identifying letter (H) and number (I).

The identifying letter is always the same for a specific component, but the identifying numbers are numbered consecutively from upper left to lower right. The terminal designation (J) is placed directly inside or outside the symbol next to the connecting wire path. Switch positions (K) are also placed directly inside or outside the symbol. The solid line (L) shows the position the switch is currently in and dash lines (M) represent other switch positions.

The circuit number (N) and wire color (O) of the wires are shown directly next to the wire path.

The same component name and identification code are used consistently on all diagrams in this section. Components can be easily cross-referenced.

# ELECTRICAL INFORMATION

## Theory Of Operation Information

The theory of operation stories divide the electrical system into individual circuits by function. Each circuit is isolated from the main wiring schematic and only shows the components that are used in it. The story contains information on function, operating conditions, and theory of operation. The circuit schematics are drawn with the components in the operating position, with the power, or battery positive, into them across the top and the ground, or battery negative, across the bottom.

## Diagnostic Information

The diagnostic procedures is used to test the complete circuit regardless of the problem or complaint. Select a symptom or system from the quick check or troubleshooting chart and follow the test procedures under that heading.

The diagnostic procedure lists:

- Test conditions
- Test sequence
- Test location
- Normal reading
- Check or test to perform if reading is not normal

When performing the test or check, be sure to set your machine up to the **TEST POINT/PROCEDURES** listed in the first column and follow the sequence carefully. The middle **RESULTS** column gives the reading or condition that should be obtained in **BOLD** print. If the results of the test or check are not normal, perform the test, check, or adjustment listed below the **BOLD** print. The system diagram that accompanies each test procedure is drawn to resemble machine components. The leader line points to the exact point the test is to be made.

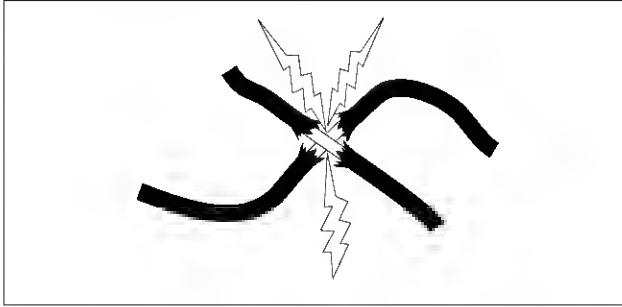
## Wire Color Abbreviation Chart

Blk	Black
Blu	Blue
Brn	Brown
Grn	Green
Gry	Gray
Org	Orange
Pnk	Pink
Pur	Purple
Red	Red
Tan	Tan
Wht	White
Yel	Yellow
Blk/Wht	Black/White
Blu/Wht	Blue/White
Brn/Wht	Brown/White
Brn/Yel	Brown/Yellow
Dk Blu	Dark Blue
Dk Brn/Lt Grn	Dark Brown/Light Green
Dk Brn/Red	Dark Brown/Red
Dk Brn/Yel	Dark Brown/Yellow
Dk Grn	Dark Green
Lt Blue	Light Blue
Lt Grn	Light Green
Org/Wht	Orange/White
Pnk/Blk	Pink/Black
Pur/Wht	Purple/White
Red/Blk	Red/Black
Red/Wht	Red/White
Wht/Blk	White/Black
Wht/Red	White/Red
Yel/Blk	Yellow/Black
Yel/Red	Yellow/Red
Yel/Wht	Yellow/White

# ELECTRICAL INFORMATION

## Common Circuit Tests

### Shorted Circuit:

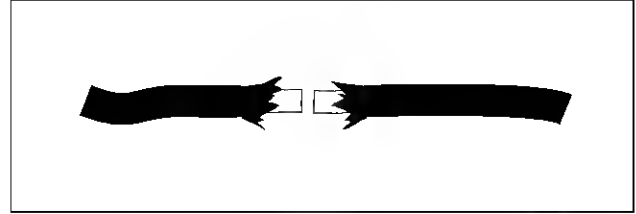


M85600 MIF

A shorted circuit may result in the wrong component operating (i.e. improper wire-to-wire contact). To test for a shorted or improperly wired circuit:

1. Turn component switch ON.
2. Start at the controlling switch of the component that should not be operating.
3. Follow the circuit and disconnect wires at connectors until component stops operating.
4. Shorted or improper connections will be the last two wires disconnected.

### High Resistance or Open Circuit:

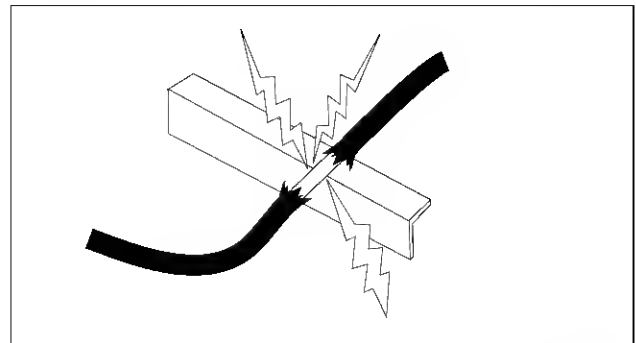


M85601 MIF

High resistance or open circuits usually result in slow, dim or no component operation (i.e. poor, corroded, or disconnected connections). Voltage at the component will be low when the component is in operation. To test for high resistance and open circuits:

1. Check all terminals and grounds of the circuit for corrosion.
2. If terminals are not corroded or loose, the problem
3. is in the component or wiring.

### Grounded Circuit:



M85602 MIF

Grounded circuits usually result in no component operation or a blown fuse.

## Conductors For 12 Volt Circuits

STRANDED CONDUCTORS FOR 12 VOLT CIRCUITS						
SAE Wire Size (Gauge)	20	18	16	14	12	10
Metric Wire Size (MM)	0.8	0.8	1.0	2.0	3.0	5.0
Typical Stranding	7 X 28	16 X 30	19 X 29	19 X 27	19 X 25	19 X 23
Minimum Conductor Area In Circular Mils	1072	1537	2336	3702	5833	9343

# ELECTRICAL SPECIFICATIONS

---

## Specifications

### System Specifications

#### Battery:

Voltage .....	12VDC
BCI Group .....	U1
CCA Rating (Amps @ -18° C (0° F) (-2007) .....	160 amps
CCA Rating (Amps @ -18° C (0° F) (2008-) .....	195 amps
Reserve Capacity (minutes) .....	20

#### Starting Motor:

Type .....	Solenoid Shift
Size .....	1.4 kW (1.88 hp)
Amp Draw (on machine) .....	85 amps (maximum) at 500 rpm
No-load amp draw (free running) .....	50 amps (maximum) at 6000 rpm
Starting Solenoid Pull-in Amp Draw .....	55.5 amps (max.)
Starting Solenoid Hold-in Amp Draw .....	10.5 amps (max.)

#### Stator:

Stator size (nominal) .....	12 VDC - 13 amps
Regulated amperage/voltage .....	.6 - 16.6 amps (minimum) at 12.2 - 13.8 volts
Unregulated voltage .....	26 VAC (minimum)

#### Fuel Shutoff Solenoid:

Voltage Range .....	.6 - 16 VDC, 12 VDC Nominal
Starting Current (maximum) .....	35 amps
Operating Current .....	0.3 amps

#### Lighting:

Headlights .....	37.5 Watts
------------------	------------



# ELECTRICAL SCHEMATICS AND HARNESES (SN -040000)

---

## Schematics and Harnesses (SN -040000)

### Schematic and Wiring Harness Legend

A1 - Interlock Module  
B1 - Engine Oil Pressure Switch (not used)  
E1 - Spark Plug  
E2 - Spark Plug  
E3 - Right Headlight  
E4 - Left Headlight  
F1 - Fuse 15A  
F2 - Fuse 10A  
F3 - Fuse 7.5A  
F4 - Fuse 7.5A  
G1 - Battery  
G2 - Alternator  
M1 - Starting Motor  
N1 - Voltage Regulator/Rectifier  
P1 - Hourmeter  
S1 - Brake Switch  
S2 - Reverse Switch  
S3 - Seat Switch  
S4 - Key Switch  
S5 - Light Switch  
S6 - PTO/RIP Switch  
W1 - Battery/Frame Ground  
Y1 - Fuel Shutoff Solenoid  
Y2 - Starting Motor Solenoid  
Y3 - PTO Clutch

### Connectors:

X1 - Power Port  
X2 - Main Wiring Harness to Engine  
X3 - Engine Wiring Harness to Fuel Shutoff Solenoid Jumper Wire  
X4 - Engine Wiring Harness to Magneto Wiring Harness  
X5 - PTO Clutch  
X6 - Main Wiring Harness to Control Panel Wiring Harness  
X7 - Main Wiring Harness to Headlight Wiring Harness  
X8 - Right Headlight  
X9 - Left Headlight  
X10 - Interlock Module

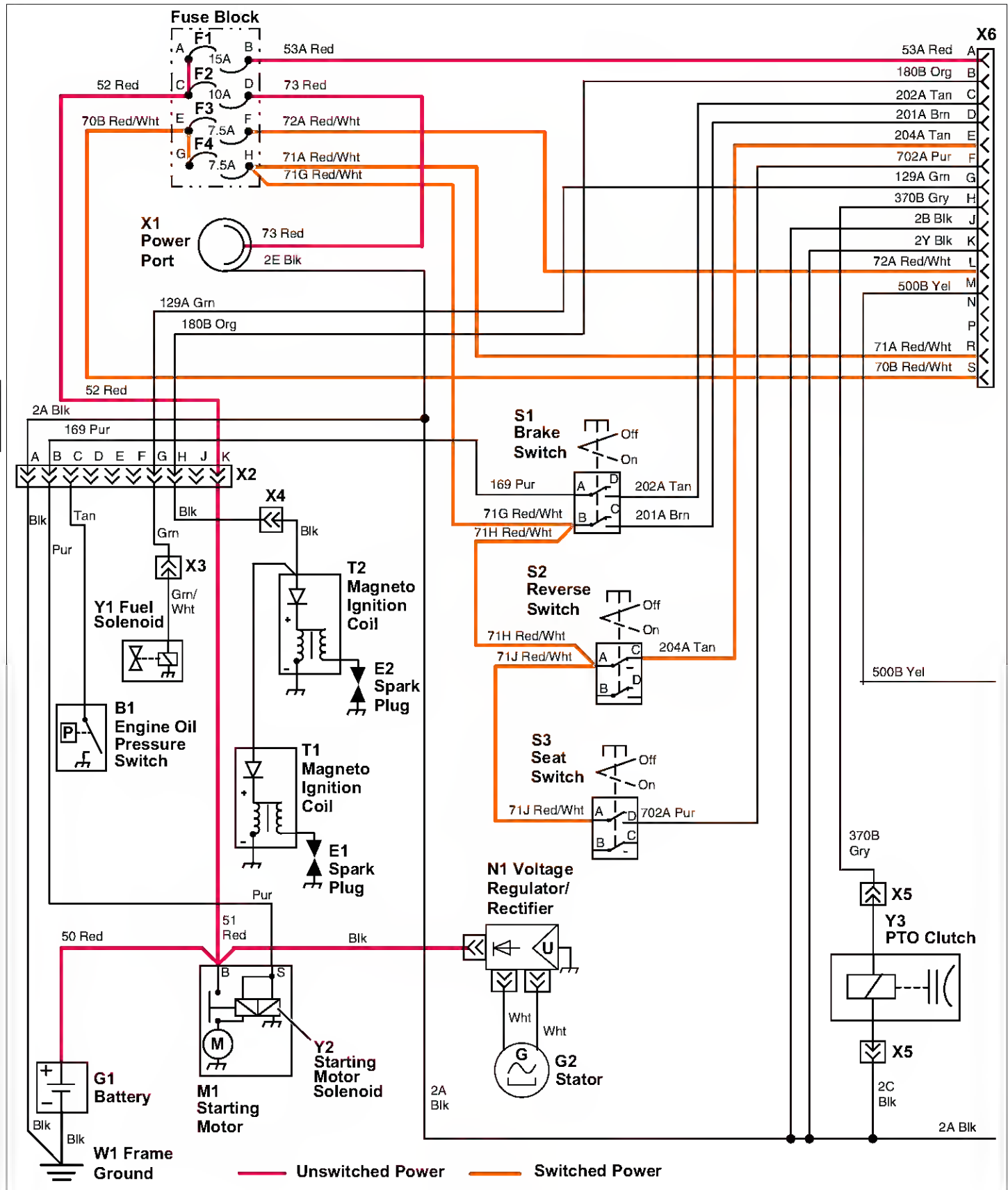
### Wiring Harnesses:

W1 - Main Wiring Harness  
W2 - Engine Wiring Harness  
W3 - Control Panel Wiring Harness  
W4 - Headlight Wiring Harness

# ELECTRICAL SCHEMATICS AND HARNESSES (SN -040000)

Main Schematic (SN -040000)

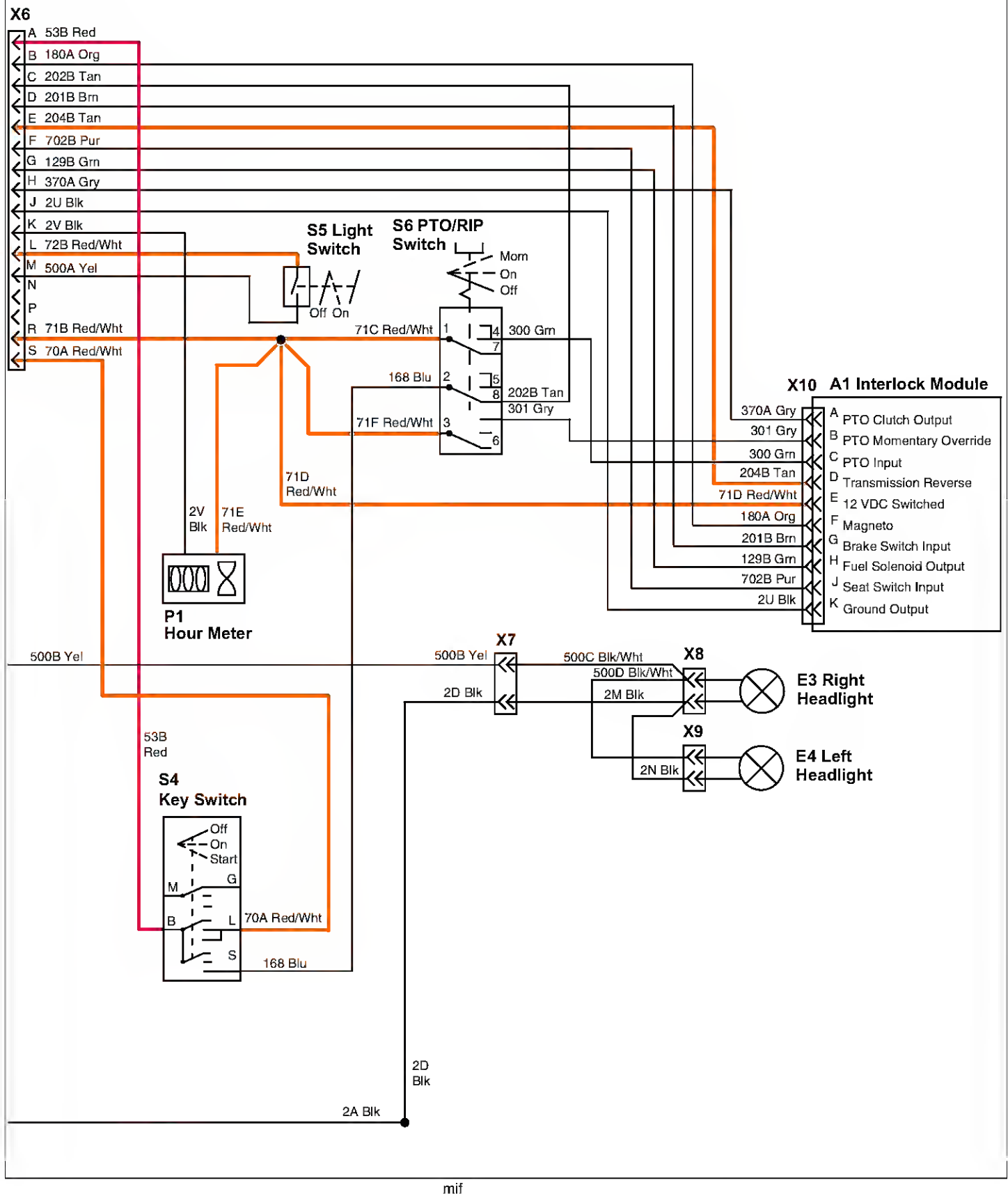
Schematic (1 of 2)



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# ELECTRICAL SCHEMATICS AND HARNESSES (SN -040000)

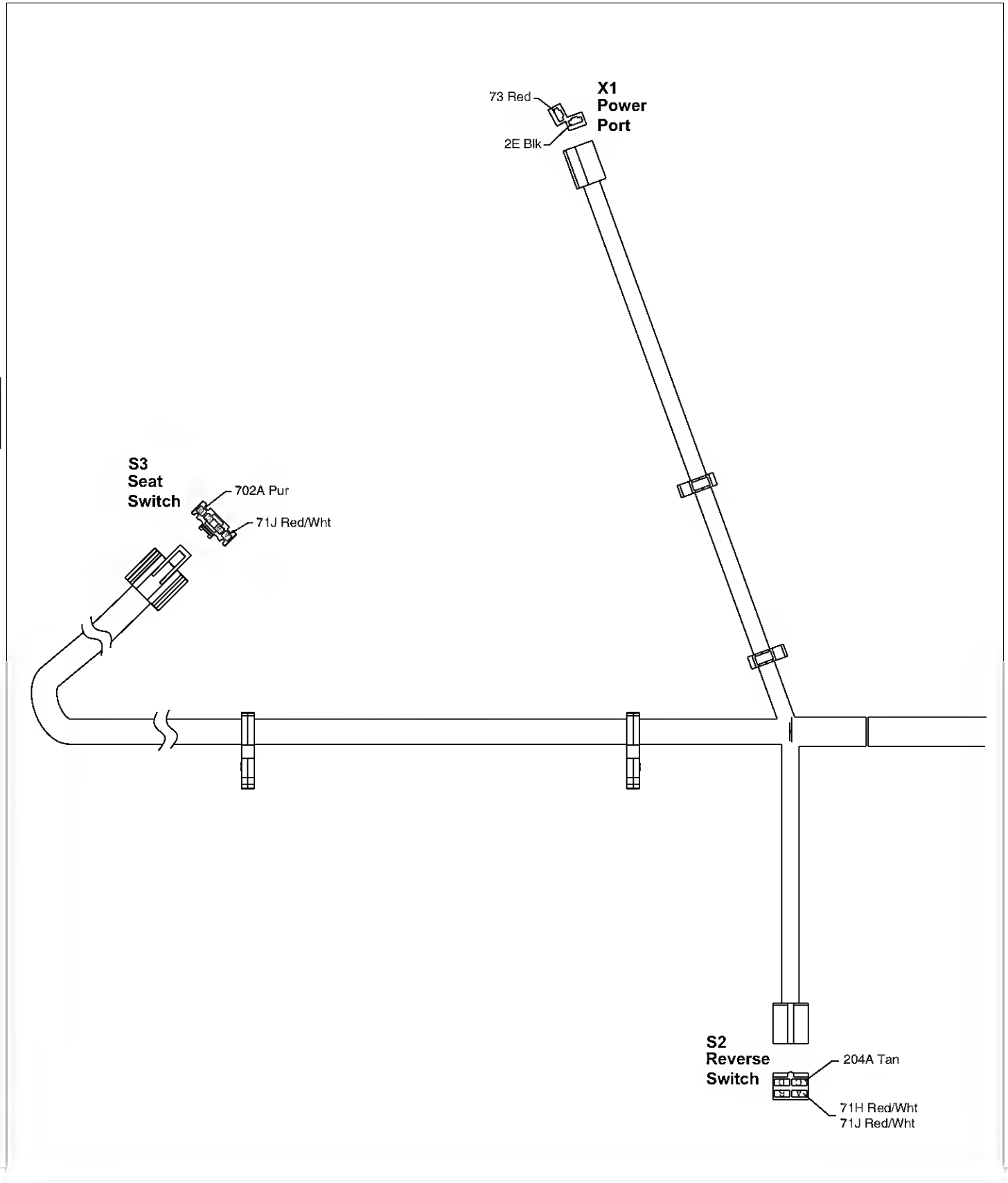
Schematic (2 of 2)



# ELECTRICAL SCHEMATICS AND HARNESSES (SN -040000)

W1 Main Wiring Harness (SN -040000)

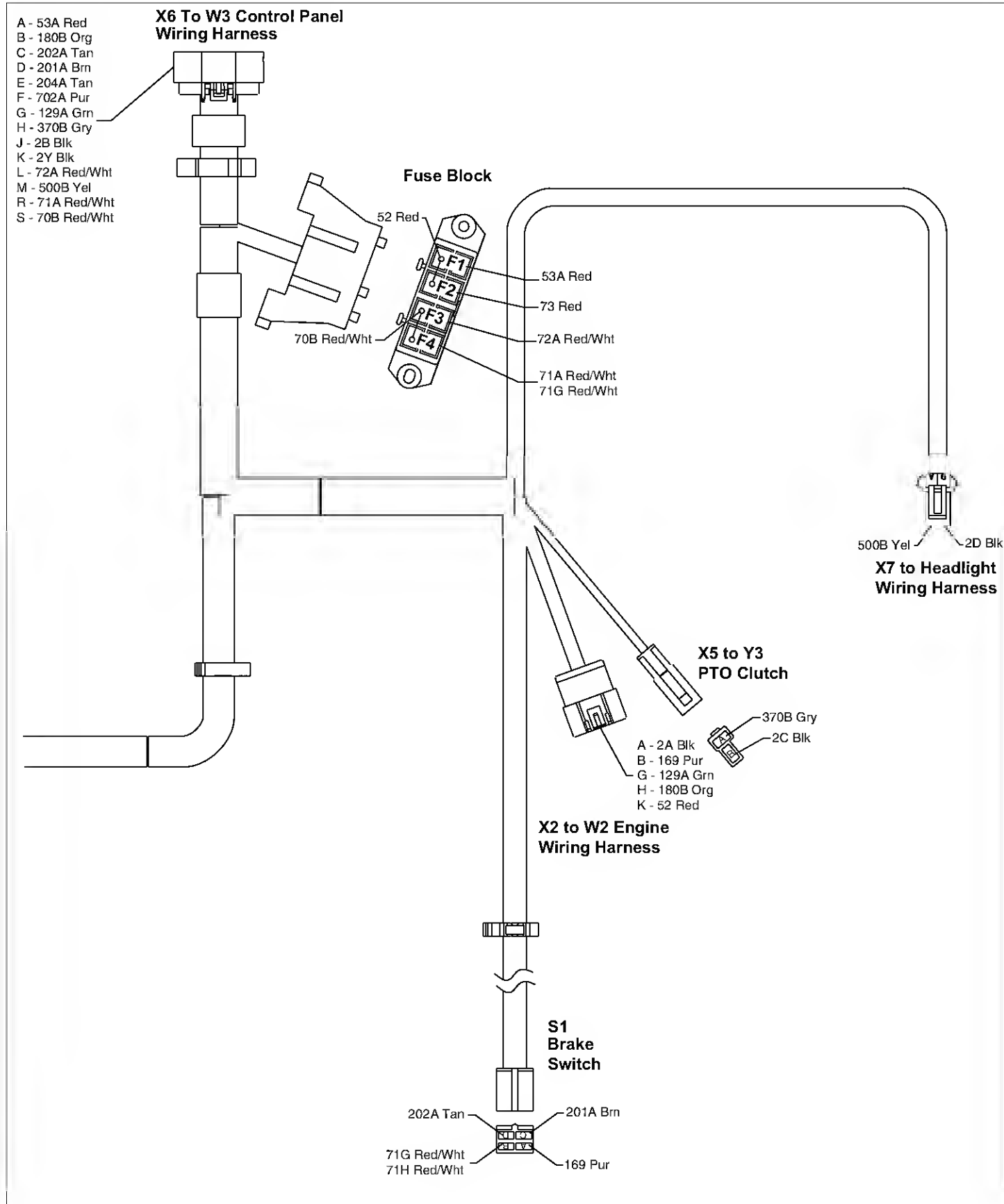
Harness (1 of 2)



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# ELECTRICAL SCHEMATICS AND HARNESSES (SN -040000)

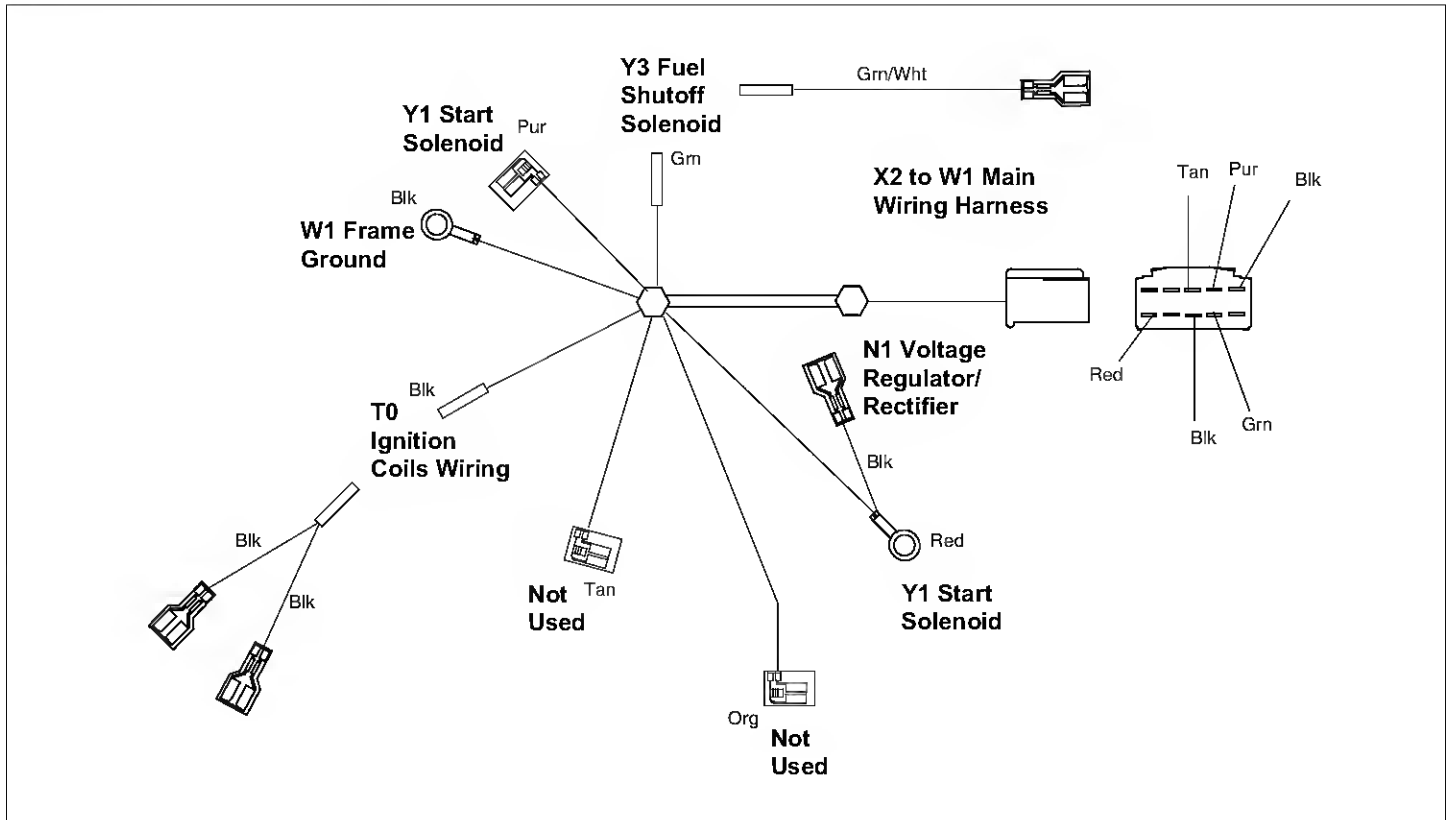
## Harness (2 of 2)



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# ELECTRICAL SCHEMATICS AND HARNESSES (SN -040000)

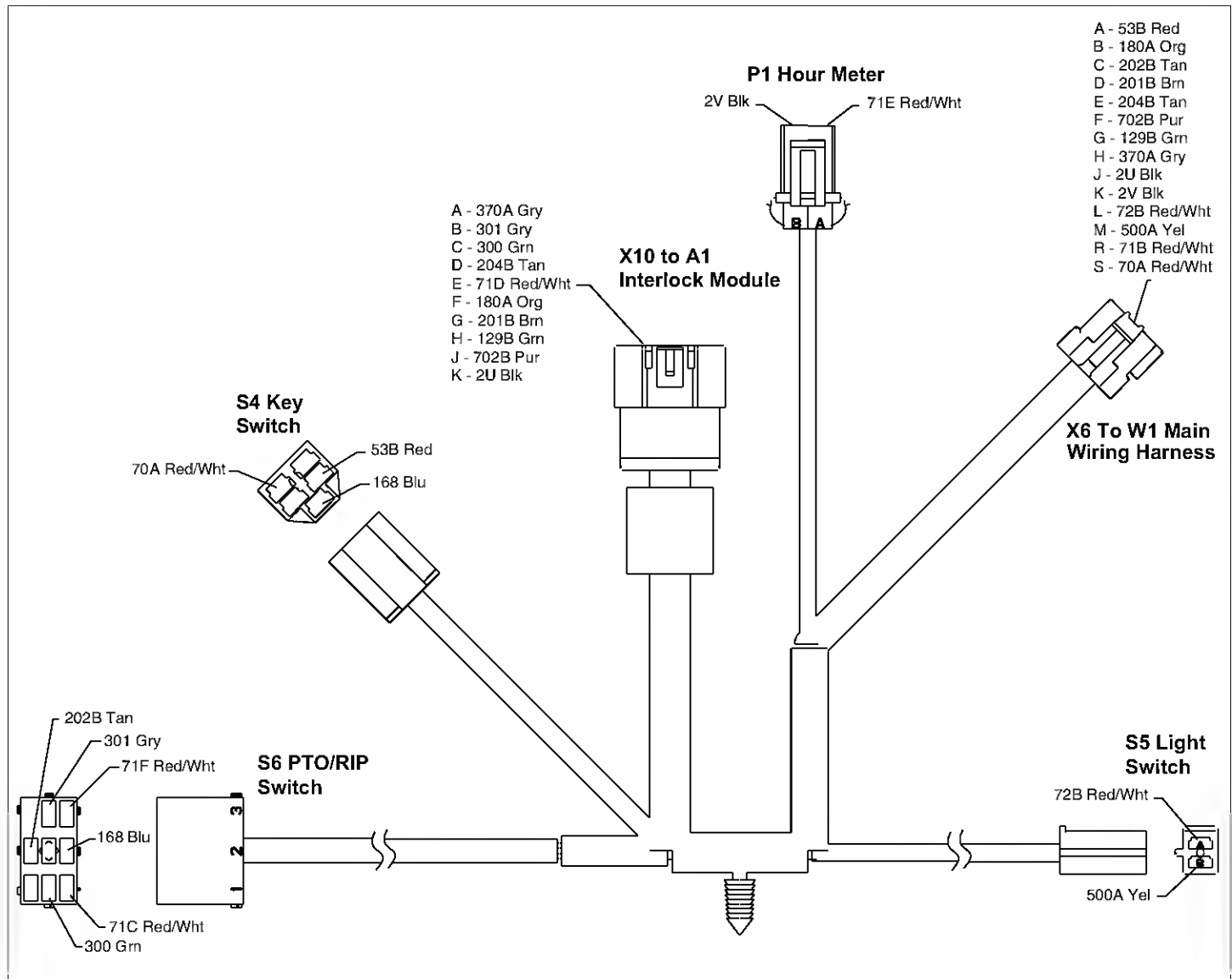
## W2 Engine Wiring Harness (SN -040000)



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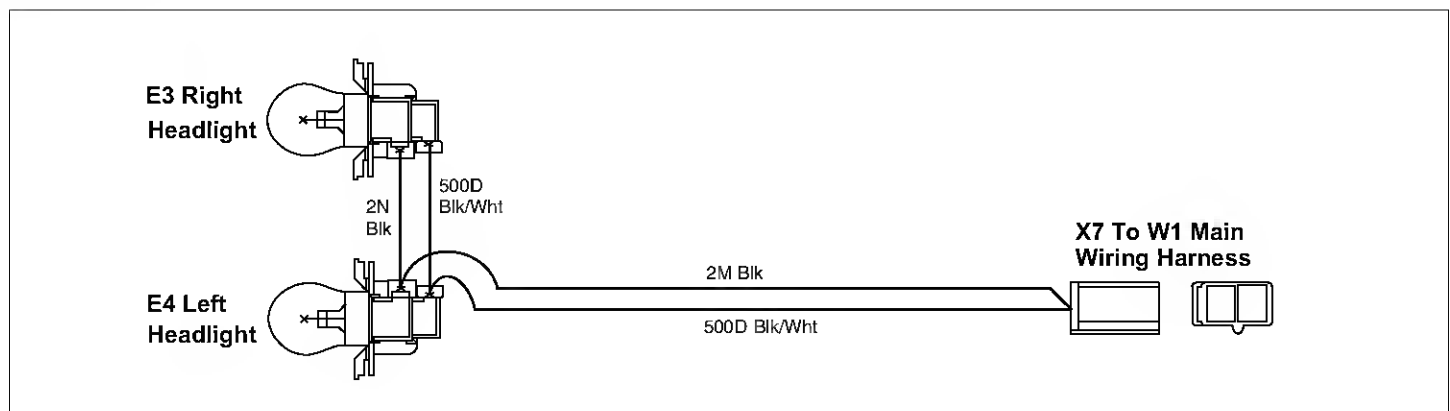
# ELECTRICAL SCHEMATICS AND HARNESSES (SN -040000)

## W3 Control Panel Wiring Harness (SN -040000)



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## W4 Headlight Wiring Harness



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# ELECTRICAL SCHEMATICS AND HARNESSSES (SN -040000)

## W1 Main Wiring Harness Color Codes

Size/No./Color	Wire Connection Points
2.0 2A Blk	X2, Splice
1.0 2B Blk	Splice, X6
1.0 2C Blk	Splice, X5
1.3 2D Blk	Splice, X7
1.6 2E Blk	Splice, X1
1.0 2Y Blk	Splice, X6
2.0 52 Red	X2, F1/F2
1.6 53A Red	F1, X6
1.6 70B Red/Wht	F3/F4, X6
1.3 71A Red/Wht	F4, X6
1.3 71G Red/Wht	F4, S1
1.3 71H Red/Wht	S1, S2
1.3 71J Red/Wht	S2, S3
1.3 72A Red	F3, X6
1.6 73 Red	F2, X1
1.0 129A Grn	X2, X6
1.0 169 Pur	S1, X2
1.0 180B Org	X2, X6
1.0 201A Brn	S1, X6
1.0 202A Tan	S1, X6
1.0 204A Tan	S2, X6
1.0 370B Gry	X5, X6
1.3 500B Yel	X6, X7
1.0 702A Pur	S3, X6

## W2 Engine Wiring Harness Color Codes

Size/No./Color	Wire Connection Points
1.6 Blk	X2, W1
1.0 Pur	X2, Y2
1.0 Tan	X2, B1 (option, not used on some models)
1.0 Grn	X2, X3
1.0 Grn/Wht	X3, Y1
1.0 Blk	X2, X4
1.0 Blk	X4, T1 and T2
2.0 51 Red	X2, Y2

## W3 Control Panel Wiring Harness Color Codes

Size/No./Color	Wire Connection Points
1.0 2U Blk	X6, X10
1.0 2V Blk	X6, P1
1.6 53B Red	X6, S4
1.6 70A Red/Wht	X6, S4
1.3 71B Red/Wht	X6, Splice
1.0 71C Red/Wht	Splice, S6
1.3 71D Red/Wht	Splice, X10
1.0 71E Red/Wht	Splice, P1
1.0 71F Red/Wht	Splice, S6
1.3 72B Red/Wht	X6, S5
1.0 129B Grn	X6, X10
1.0 168 Blu	S4, S6
1.0 180A Org	X6, X10
1.0 201B Brn	X6, X10
1.0 202B Tan	X6, S6
1.0 204B Tan	X6, X10
1.0 300 Grn	S6, X10
1.0 301 Gry	S6, X10
1.0 370A Gry	X6, X10



## **ELECTRICAL SCHEMATICS AND HARNESSES (SN -040000)**

---

<b>Size/No./Color</b>	<b>Wire Connection Points</b>
1.3 500A Yel	X6, S5
1.0 702B Pur	X6, X10

### **W4 Headlight Wiring Harness Color Codes**

<b>Size/No./Color</b>	<b>Wire Connection Points</b>
1.0 2M Blk	X7, X8
1.0 2N Blk	X8, X9
1.0 500C Blk/Wht	X7, X8
1.0 500D Blk/Wht	X8, X9

# ELECTRICAL THEORY OF OPERATION (SN -040000)

---

## Theory of Operation (SN -040000)

### Power Circuit Operation

#### Function:

To provide unswitched and switched power to the primary electrical components whenever the battery is properly connected. The power circuits are divided among the unswitched power circuit, switched power circuits (key switch in on position), and secondary power circuits. The secondary power circuit is energized when switched power is supplied to the A1 interlock module providing current to the secondary circuit. The secondary power circuit will not be energized if the A1 interlock module fails.

#### Operating Conditions, Unswitched Circuits:

Voltage must be present at the following components with the key switch in the off position.

- G1 battery positive terminal
- M1 starting motor - B terminal
- N1 voltage regulator/rectifier - Blk wire
- F1 and F2 fuses
- S4 key switch - B terminal
- X1 power port switch

The positive battery cable connects the battery to the starting motor. The starting motor bolt is used as the 12 volt DC tie point for the rest of the electrical system. The 51 and 52 Red wires supply voltage the F1 and F2 fuses. The F1 fuse protect the circuit to the key switch while the F2 fuse protect the power port circuit. The battery cables and the starting motor tie point connections must be good for the machine's electrical system to work properly. Proper starting motor operation depends on the battery cables to carry high current. The ground cable connection is equally as important as the positive cable connection in maintaining electrical system integrity.

#### Operating Conditions, Switched Circuits:

With the key switch in on position, PTO/RIP switch off, brake unlocked, transmission in neutral, and operator off the seat, switched voltage should be present at the following components:

- S1 key switch - terminal "L"
- F3 and F4 fuses
- S5 light switch - 72B Red/Wht wire
- S1 brake switch - 71G Red/Wht wire
- S2 reverse switch - 71H Red/Wht wire
- S3 seat switch - 71J Red/Wht wire
- A1 interlock module - terminal E, 71G Red/Wht wire

- A1 interlock module - terminal D, 204B Tan wire
- S6 PTO/RIP switch - 71C and 71F Red/Wht wires
- P1 hour meter, 71G Red/Wht wire

These circuits are controlled by the key switch and are protected by the F3 and F4 fuses and the unswitched circuits.

With power now available at various locations on the machine, the electrical system is ready to perform the different functions of starting and running the engine, engine monitoring lights, the PTO clutch and the PTO system interlocks, and the headlights.

The ground circuit is equally important as the power circuit connections. Proper systems operation depends on good wires and connections in order to carry the current needed to operate the various components.

#### Operating Conditions, Secondary Switched Circuits:

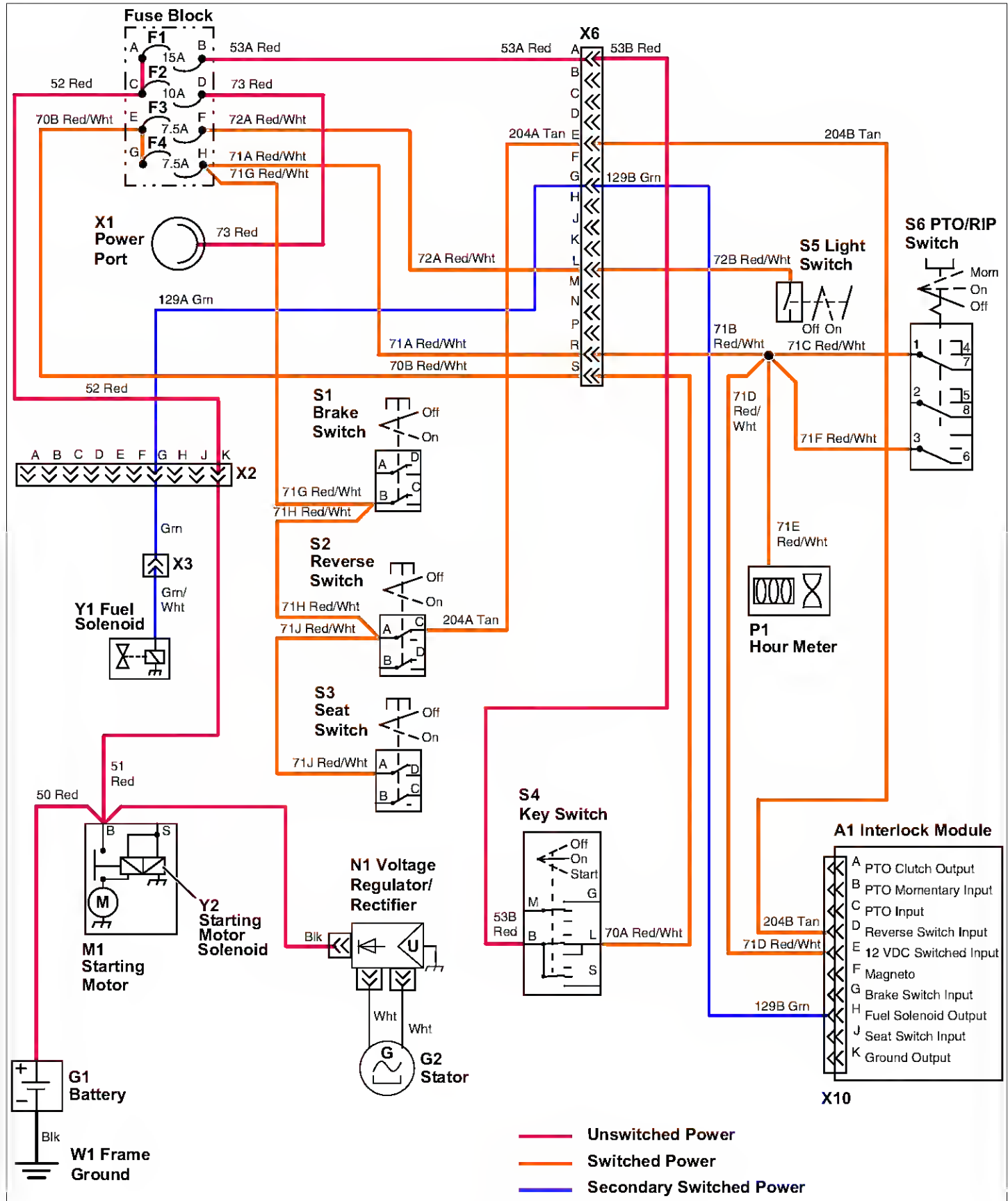
Secondary switched voltage must be present at the following components during the following conditions: Key switch in on position, transmission in neutral, PTO/RIP in off position, brake unlocked, and operator off seat:

- Y1 fuel shutoff solenoid - 129A Grn and Grn/Wht wires

This circuit is controlled by the A1 interlock module and is protected by the F1 and F4 fuses.

# ELECTRICAL THEORY OF OPERATION (SN -040000)

## Power Circuit Schematic



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# ELECTRICAL THEORY OF OPERATION (SN -040000)

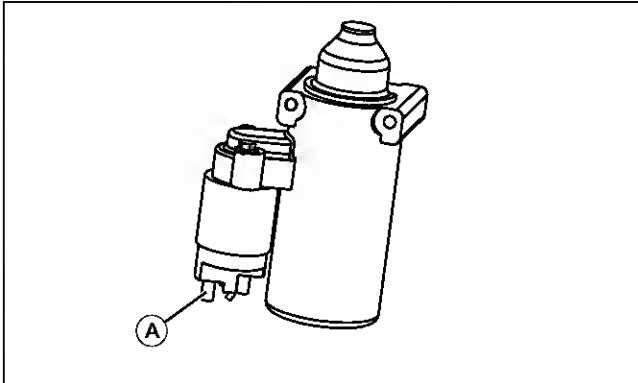
## Power Circuit Diagnostics

### Test Procedure A:

#### Test Conditions:

- Battery properly connected
- Key switch off

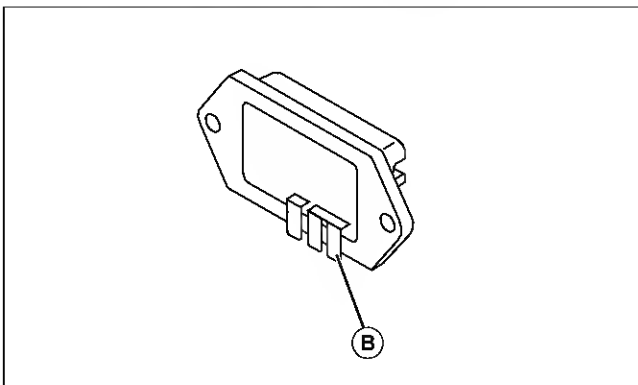
#### Unswitched Power:



1. Is battery voltage present at the starting motor solenoid (A)?

Yes: Go to next step.

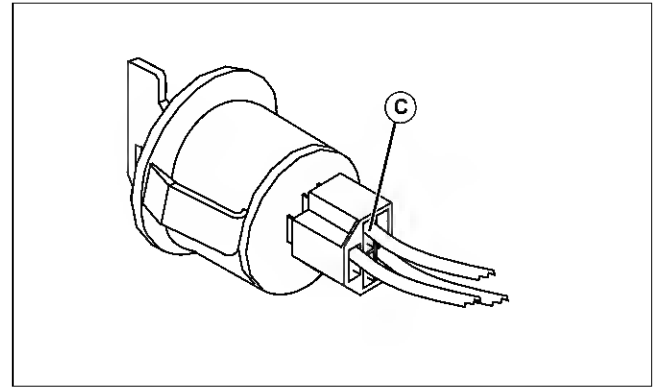
No: Check the battery connections. If ok, test the battery. See "Battery Test" on page 343.



2. Is battery voltage present at the voltage regulator (B)?

Yes: Go to next step.

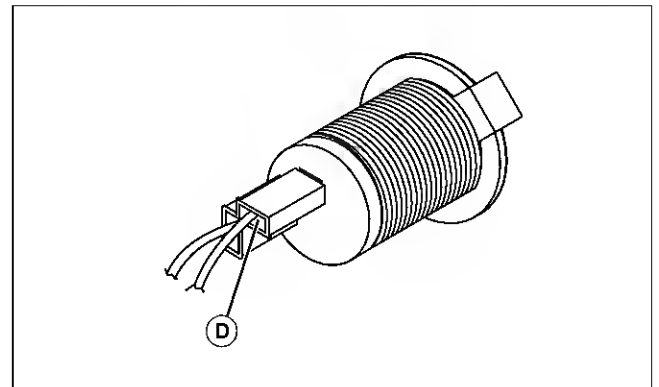
No: Check the Blk wire and battery connections. If ok, test the battery. See "Battery Test" on page 343.



3. Is battery voltage present at the key switch (C)?

Yes: Go to next step.

No: Check F1 fuse. Check the 51, 52, 53A, and 53B Red wires and connections. If ok, test the battery. See "Battery Test" on page 343.



4. Is battery voltage present at the power port (D)?

Yes: Go to switched power tests.

No: Check F2 fuse. Check the 51, 52, and 73 Red wires and connections. If ok, test the battery. See "Battery Test" on page 343.

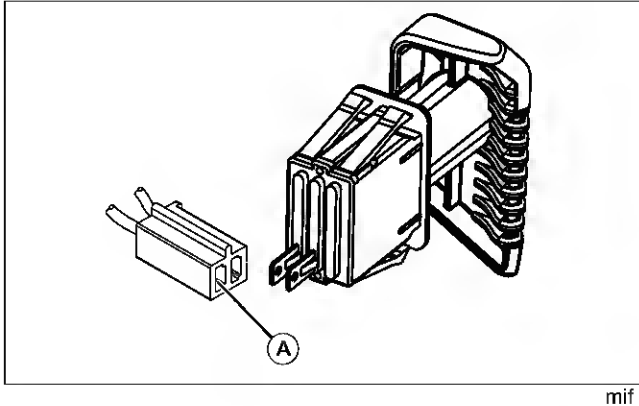
# ELECTRICAL THEORY OF OPERATION (SN -040000)

## Test Procedure B:

### Test Conditions:

- Key switch on
- All other switches off

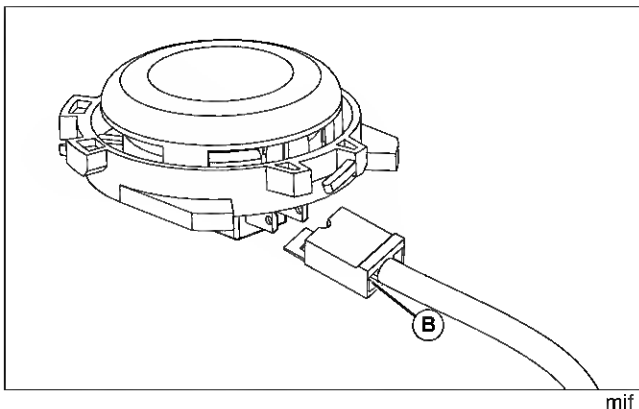
### Switched Power:



1. Is battery voltage present at the light switch (A)?

Yes: Go to next step.

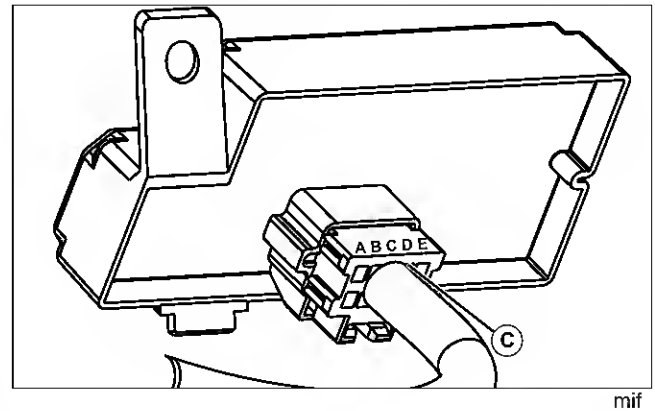
No: Check F3 fuse. Check the 70A, 70B, 72A, and 72B Red/Wht wires and connections. If ok, replace key switch.



2. Is battery voltage present at the seat switch (B)?

Yes: Go to next step.

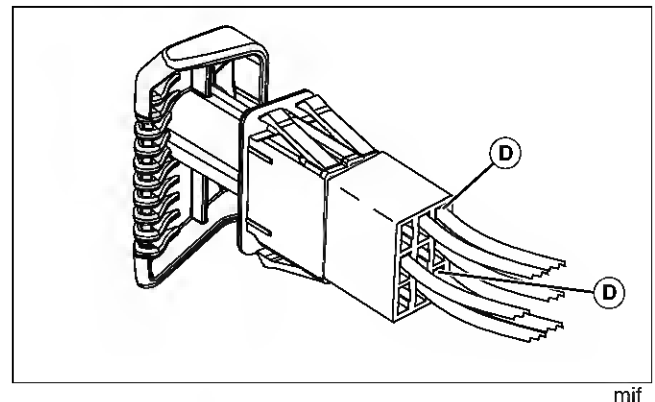
No: Check F4 fuse. Check the 70A, 70B, 71G, 71H, and 71J Red/Wht wires and connections. If ok, replace key switch.



3. Is battery voltage present at the interlock module terminal D (C)?

Yes: Go to next step.

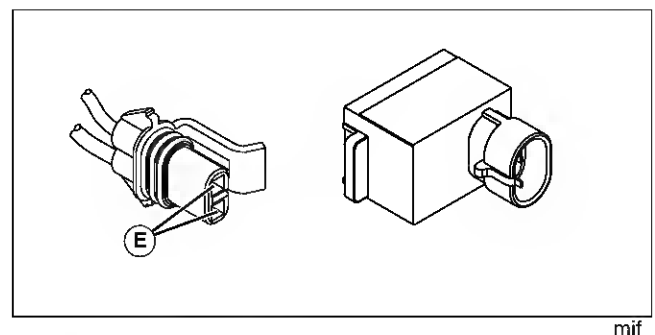
No: Check F4 fuse. Check the 70A, 70B, 71G, 71H Red/Wht, 204A, and 204B Tan wires and connections. If ok, replace reverse switch.



4. Is battery voltage present at the PTO/RIP switch (D)?

Yes: Go to next step.

No: Check F4 fuse. Check the 70A, 70B, 71A, 71B, 71C, and 71F Red/Wht wires and connections. If ok, replace key switch.



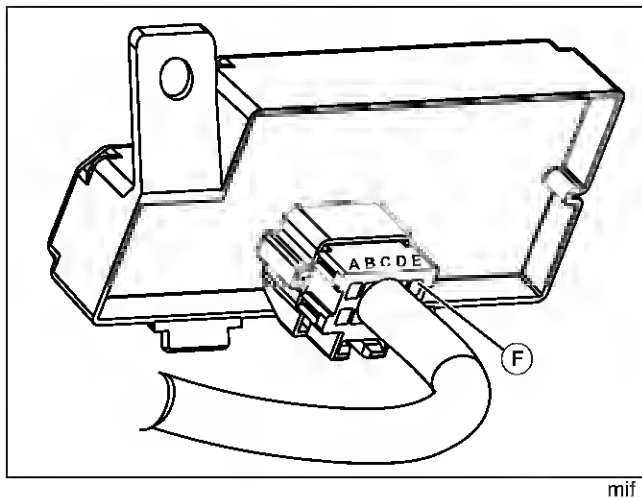
5. Disconnect the harness from the hour meter. Is battery voltage present across the wiring harness connector terminals (E)?

## ELECTRICAL THEORY OF OPERATION (SN -040000)

---

Yes: Connect the wiring harness to the hour meter. Go to next step.

No: Check F4 fuse. Check the 70A, 70B, 71A, 71B, and 71E Red/Wht wires and connections. If ok, replace key switch.



6. Is battery voltage present at the interlock module terminal E (F)?

Yes: Test complete.

No: Check F4 fuse. Check the 70A, 70B, 71A, 71B, and 71D Red/Wht wires and connections. If ok, replace key switch.

## Cranking Circuit Operation

### Function:

To energize the starting motor solenoid and engage the starting motor to crank the engine.

### Operating Conditions:

- Key switch in start position.
- Brake locked, switch closed.
- PTO/RIP switch in off position.

### Theory of Operation:

The starting motor is a solenoid shift design. The power circuit provides current to the S4 key switch and protects the cranking circuit with the F1 fuse. Current flows from the battery positive (+) terminal to the starter solenoid battery terminal, 51 and 52 Red wires, F1 fuse, 53A and 53B Red wires and to the key switch.

With the key switch in the start position, the secondary power circuit is energized, thereby providing power to the the A1 interlock module. This circuit is used to provide current to the fuel shutoff solenoid. See “Fuel Shutoff Solenoid Circuit Operation” on page 252. At the same time, secondary power is provided through the key switch to the 168 Blu wire, PTO/RIP switch (normally closed contacts), 202B and 202A tan wires, brake switch (brake locked), 169 Pur and Pur wire (engine harness) wire to the Y2 starting motor solenoid.

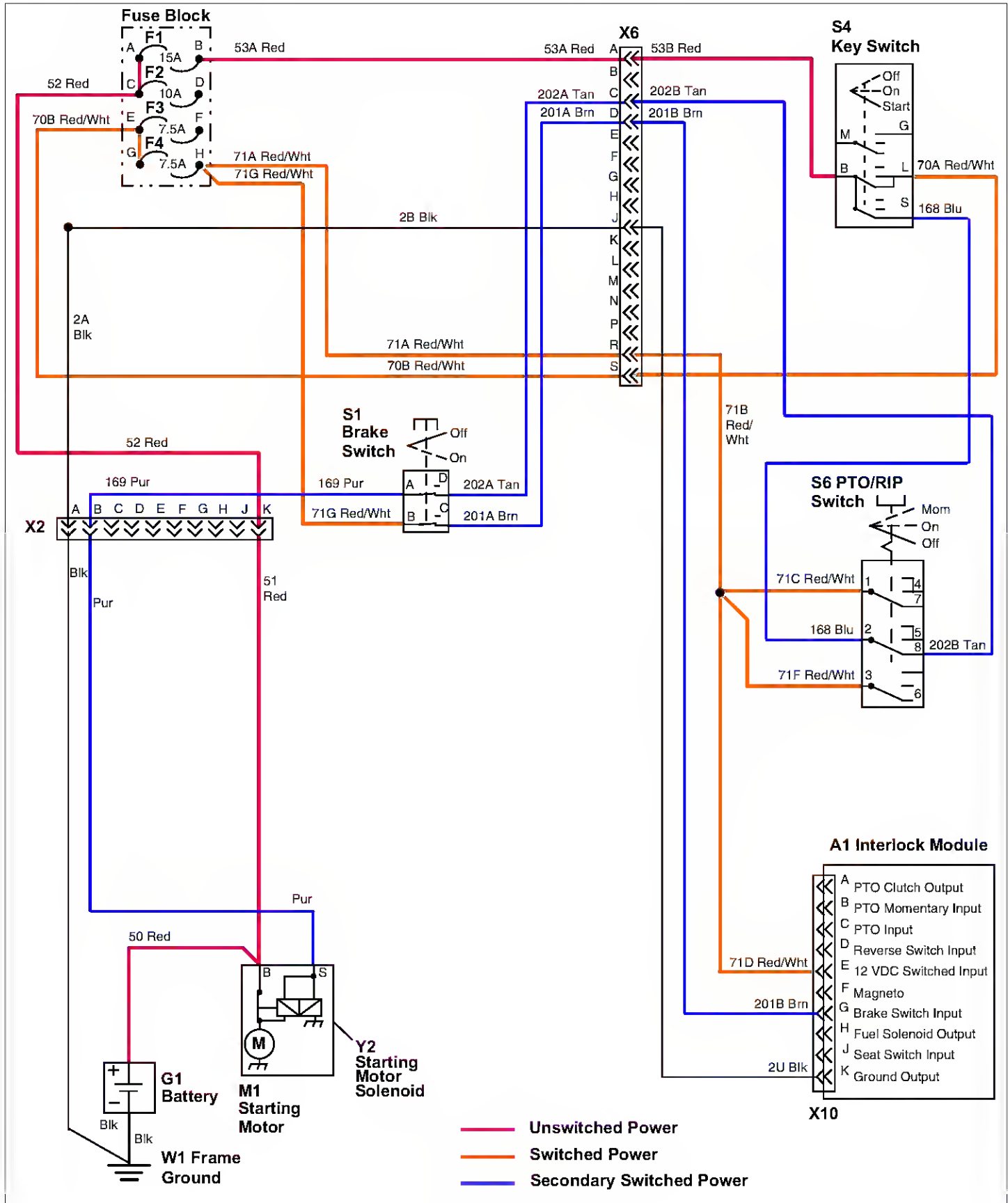
The Y2 starting motor solenoid is engaged by current flowing through the coil windings, pulling the plunger inward. The plunger closes the solenoid main contacts. Current flows through the hold-in windings, keeping the solenoid engaged.

With the solenoid main contacts closed, high current from the battery flows across the main contacts to the M1 starting motor causing it to turn.

With the starting motor cranking the engine, the A1 interlock module must receive an input from the brake switch to allow for output to the fuel shutoff solenoid (See “Fuel Shutoff Solenoid Circuit Operation” on page 252), as well as to open the ground path for the magnetos (See “Ignition Circuit Operation” on page 242). This circuit uses switch power from the 71G Red/Wht wire across the brake switch (brake locked) to the 201A and 201B Brn wires to the A1 interlock module.

# ELECTRICAL THEORY OF OPERATION (SN -040000)

## Cranking Circuit Schematic



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# ELECTRICAL THEORY OF OPERATION (SN -040000)

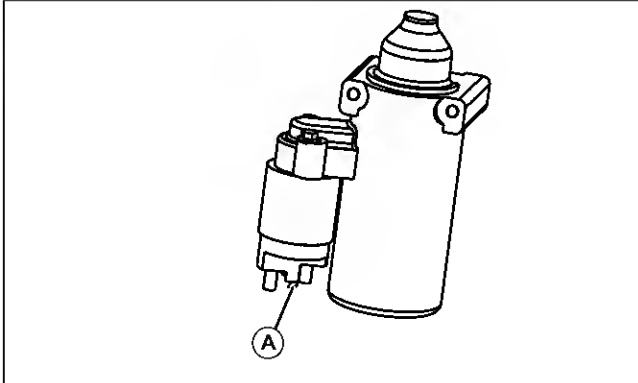
## Cranking Circuit Diagnostics

### Test Procedure A:

#### Test Conditions:

- Park machine safely.
- Key switch in START position
- PTO/RIP switch OFF
- Park brake ON

#### Cranking Power:

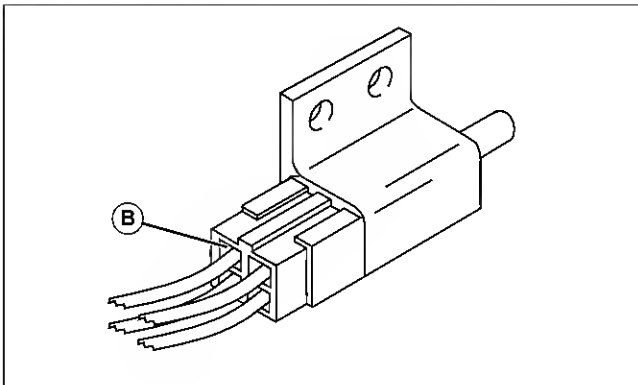


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1. Is battery voltage present at the starting motor solenoid (A)?

Yes: Cranking circuit is operational. Test the starting solenoid and the starting motor. See "Starting Solenoid Test" on page 349.

No: Go to next step.

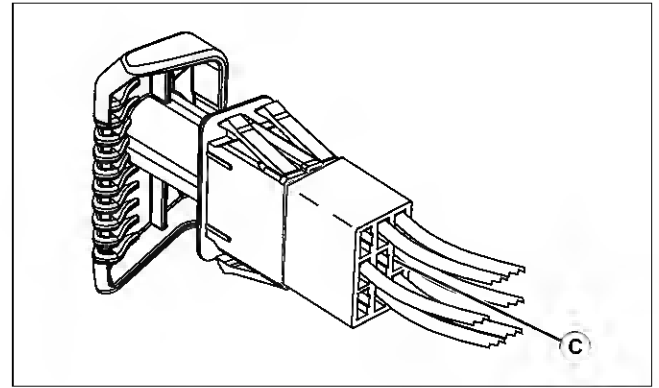


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2. Is battery voltage present at the brake switch (B)?

Yes: Check the 169 Pur and Pur engine harness wires and connections. If ok, replace the brake switch.

No: Go to next step.

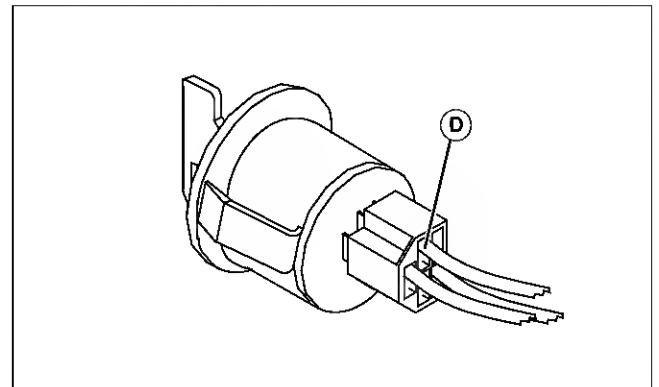


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3. Is battery voltage present at the PTO/RIP switch (C)?

Yes: Check the 202A and 202B Tan wires and connections. If ok, replace the PTO/RIP switch.

No: Go to next step.



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4. Is battery voltage present at the key switch (D)?

Yes: Check the 168 Blu wire and connections. If ok, replace the key switch.

No: Check the F1 fuse. Check the 51, 52, 53A, and 53B Red wires and connections. Test the battery. See "Battery Test" on page 343. Test complete.

# ELECTRICAL THEORY OF OPERATION (SN -040000)

---

## Ignition Circuit Operation

### Function:

To control the ignition coils ability to create a spark.

### Operating Conditions, Stopping Engine:

- Key switch in off position,
- or,
- Operator off seat,
- and,
- Park braked unlocked.

### Theory of Operation, Stopping Engine

The engine is shut off by grounding the T1 and T2 ignition coils. With the ignition primary coil grounded, a spark cannot be produced.

When the S4 key switch is in the off position, a path to ground is created through the interlock module.

The interlock module uses switched power from the key switch to turn on and operate. With switched power removed from the interlock module, the interlock module switches the 180A Org wire from the ignition coils to ground.

With both switched input power from the key switch (71D Red/Wht wire) and logic input from the seat switch (702B Pur wire) and the brake switch (201B Brn wire) removed from the interlock module, the interlock module switches the 180A Org wire from the magnetos to ground.

The seat switch or brake switch also provide an input to the interlock module for the fuel shutoff solenoid circuit. If both the seat switch and the brake switch are in the off position the fuel shutoff solenoid is also de-energized and fuel flow to the carburetor is stopped, stopping the engine.

### Operating Conditions, Running Engine:

- Key switch in on or start position,
- or,
- Key switch in on or start position,
- Operator on seat,
- Operator off seat,
- Park braked locked.

### Theory of Operation, Running Engine:

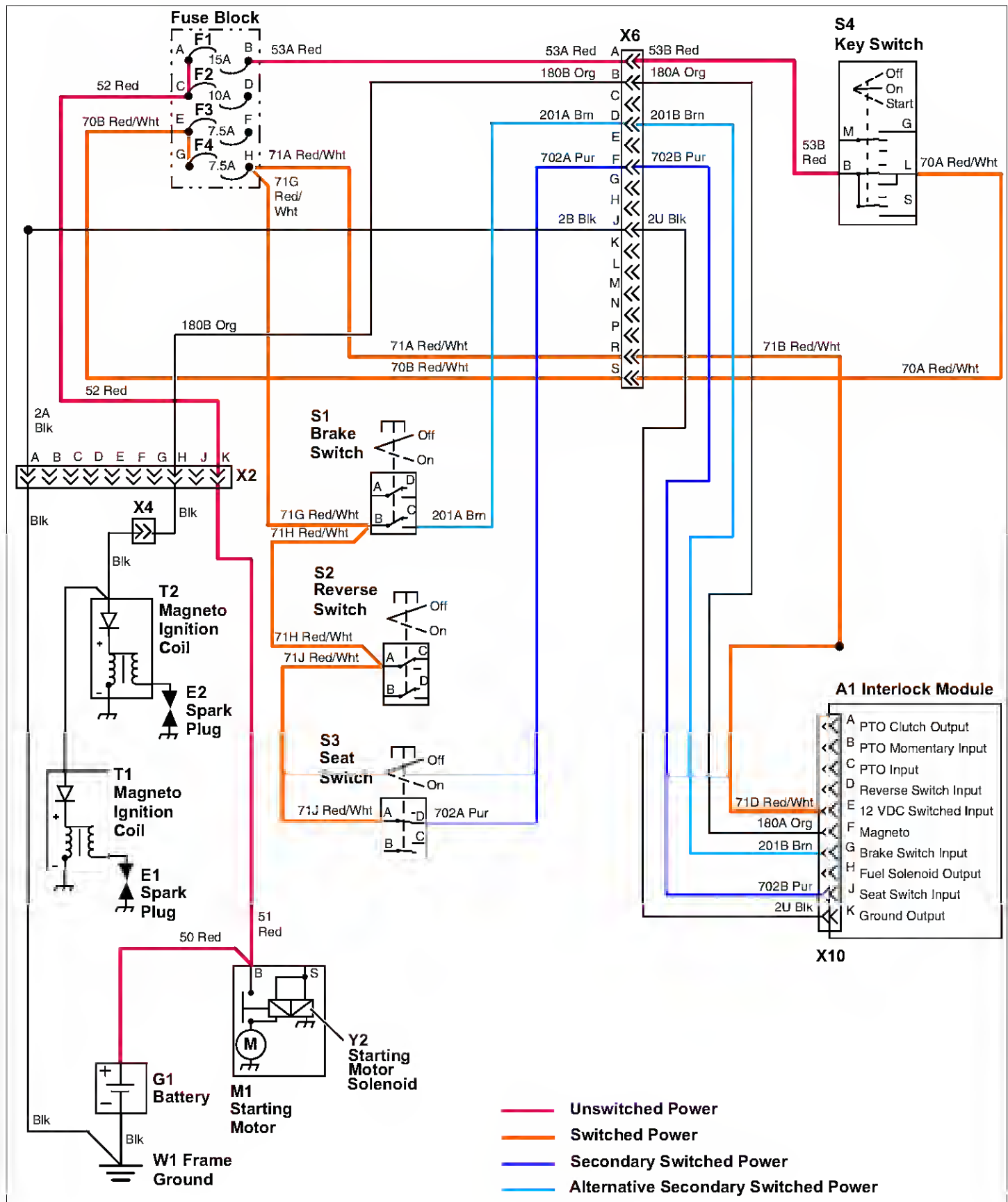
The ignition system is a transistor-controlled magneto design. Ignition timing is controlled by the transistor and is not adjustable. As the engine turns over the flywheel magnet induces current into the magneto ignition coil, which in turn produces current high enough to jump the spark plug(s) gap, creating spark to ignite the engine fuel/air mixture.

The components within the interlock module are solid state and are not serviced separately.

The key switch supplies switched power to the interlock module through the 70A, 70B, 71A, 71B, and 71D Red/Wht wires. With a proper ground, this powers up the interlock module. The module will then open the ground path for the ignition coils allowing them to produce a spark. Additionally, the interlock module supplies power to the fuel shutoff solenoid to open the solenoid and allow fuel to flow within the carburetor. See "Fuel Shutoff Solenoid Circuit Operation" on page 252.

# ELECTRICAL THEORY OF OPERATION (SN -040000)

## Ignition Circuit Schematic



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# ELECTRICAL THEORY OF OPERATION (SN -040000)

## Ignition Circuit Diagnostics

### Test Procedure A:

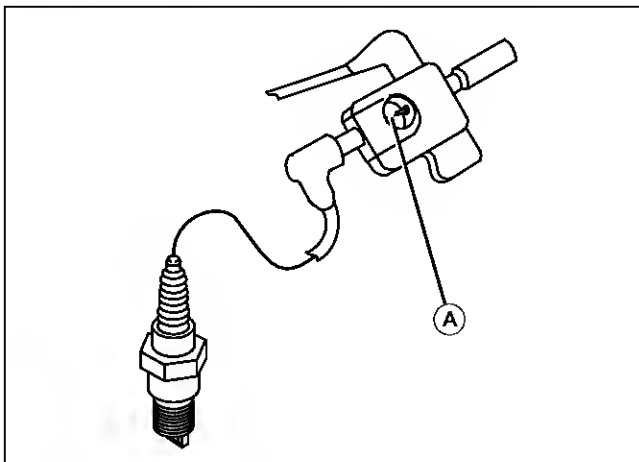


**Caution: Avoid Injury! Stay clear of moving parts. Engine will turn over and may start during this test.**

#### Test Conditions:

- Machine parked safely with park brake locked.
- Ignition spark tester installed between spark plug and spark plug lead.
- PTO off.
- Fuel shutoff solenoid disconnected to prevent starting.
- Key switch in start position, engine cranking during test.

#### Spark Test:



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1. Does the spark tester (A) indicate a hot, blue spark?

Yes: Check spark plug gap and condition of spark plug. If plug is good, continue testing ground circuit.

No: Test ignition coil and ignition module. Check armature air gap See "Ignition Coil Replacement and Adjustment" on page 360, and flywheel magnets. See "Flywheel Ignition Magnet Test" on page 348. If ok, go to next procedure.

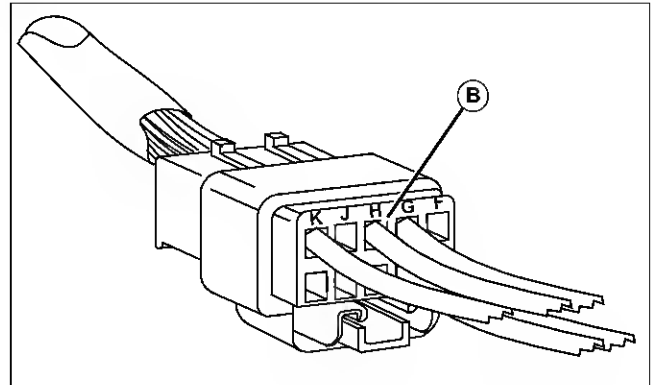
Repeat procedure for opposite spark plug.

### Test Procedure B:

#### Test Conditions:

- Machine parked safely with park brake locked.
- Key switch in off position.

#### Ignition Off:

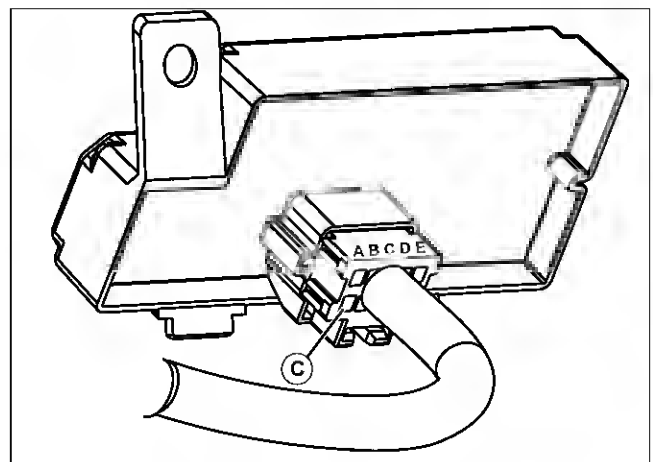


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1. Is there continuity (approximately 11.5 k ohms) between X2 connector 180B Org wire (B) and ground?

Yes: Go to next step.

No: Check 180B and 180A Org wires and connections. Go to next step.



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2. Is there continuity between X10 connector at the interlock module terminal K, 2U Blk wire (C) and ground?

Yes: Replace the interlock module.

No: Check 2U, 2B, and 2A Blk wires and connections.

# ELECTRICAL THEORY OF OPERATION (SN -040000)

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## PTO/RIP Circuit Operation

- Turn off and latch off the electric clutch if the operator enables the brake switch.

### PTO Clutch Operating Conditions:

- Key switch On
- Operator on seat
- PTO/RIP switch On
- Brake released
- Transmission in forward or neutral

or;

- Key switch ON
- Operator on seat
- Brake released
- PTO/RIP switch in Mom position while transmission shifted to reverse, then PTO/RIP switch in On position while transmission in reverse.

### Theory of Operation:

The PTO is electro/mechanical device (electric clutch) controlled by a 12 VDC output from the A1 Interlock Module.

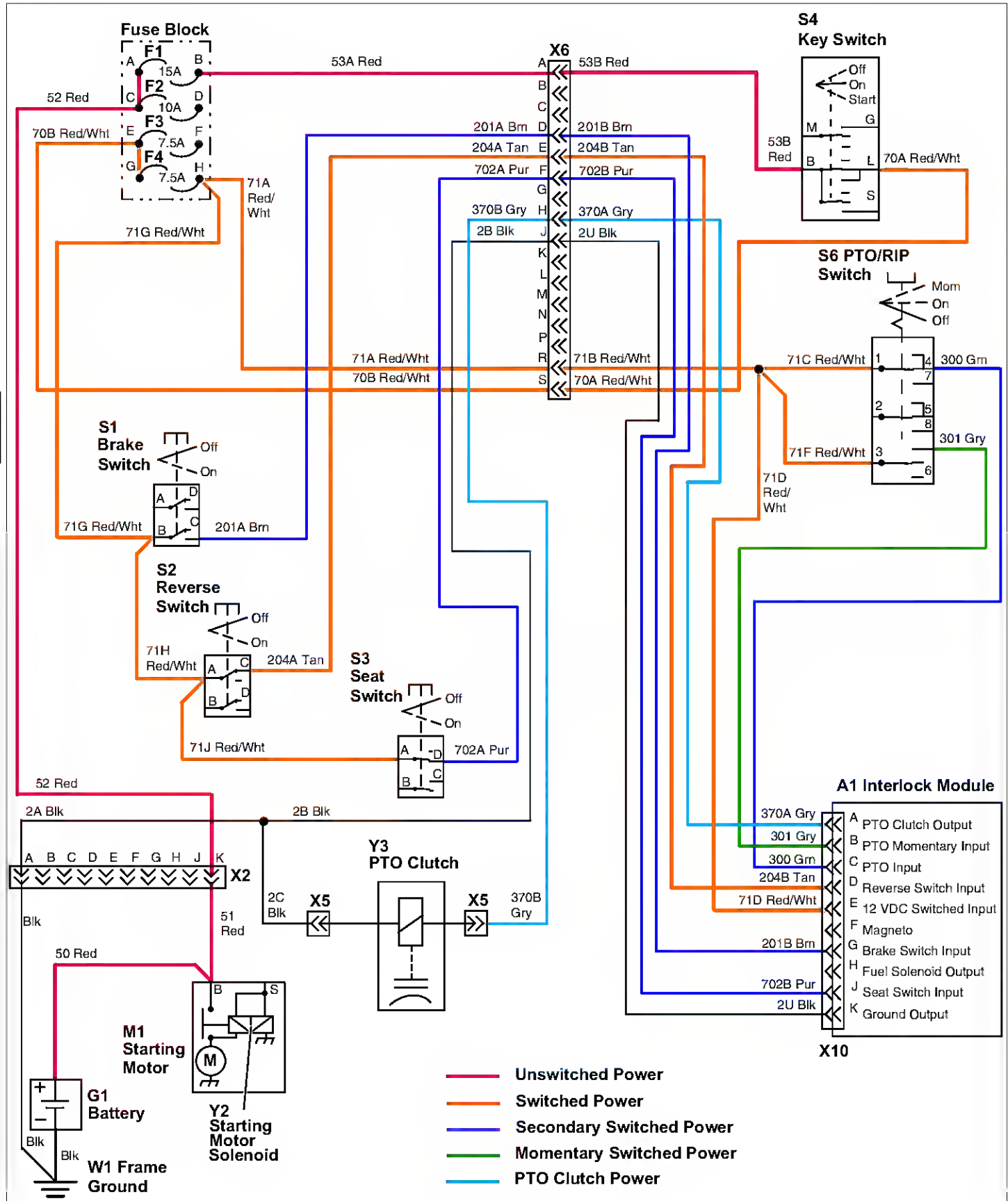
The engine crankshaft drives the PTO clutch. When the operating condition are met, the interlock module supplies 12 VDC output (Pin A) which engages the PTO electric clutch. The clutch sheave is then engaged with the engine crankshaft. The interlock module is programmed to disengage the PTO clutch when the operating conditions are not met.

### The Interlock Module Performs the Following Functions:

- Turn on the electric clutch if the operator is in the seat, the PTO/RIP switch is in the ON position, and the transmission is in forward or neutral.
- Maintain power to the electric clutch if the operator is in the seat, and chooses to mow in reverse by lifting the PTO/RIP switch to the Momentary ON position while shifting into reverse to enable the reverse override function. The reverse override function latches the power to the clutch.
  - Disables reverse override when the operator shifts the transmission from reverse to forward or neutral.
- Turn off and latch off the electric clutch if the PTO is on and the operator shifts into reverse without lifting the PTO/RIP switch. To reset the latch the operator must place the PTO/RIP switch in the OFF position.
- Turn off and latch off the electric clutch if the operator gets off the seat. A short time delay protects against bouncing. To reset the latch the operator must place the PTO/RIP switch in the OFF position.

# ELECTRICAL THEORY OF OPERATION (SN -040000)

## PTO/RIP Circuit Schematic



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# ELECTRICAL THEORY OF OPERATION (SN -040000)

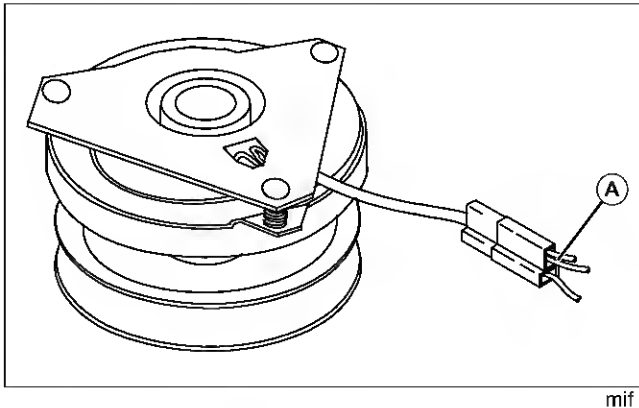
## PTO/RIP Circuit Diagnostics

### Test Procedure A:

#### Test Conditions:

- Brake unlocked
- Transmission in neutral
- Operator on seat
- Key switch on, engine not running
- PTO/RIP switch on

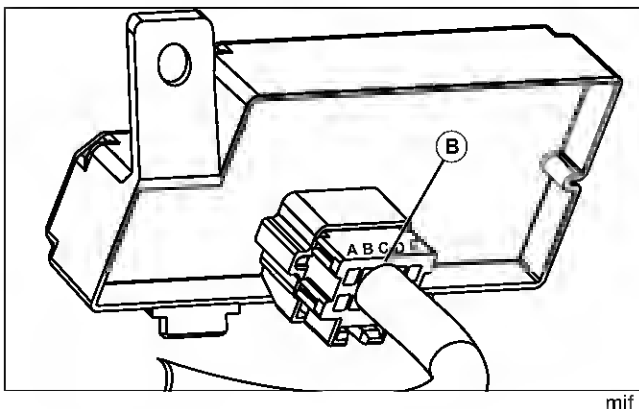
#### PTO On:



1. Is battery voltage present at the PTO clutch connector X5 (A)?

Yes: PTO clutch circuit is functional. Test the PTO clutch. See "PTO Clutch Test" on page 353.

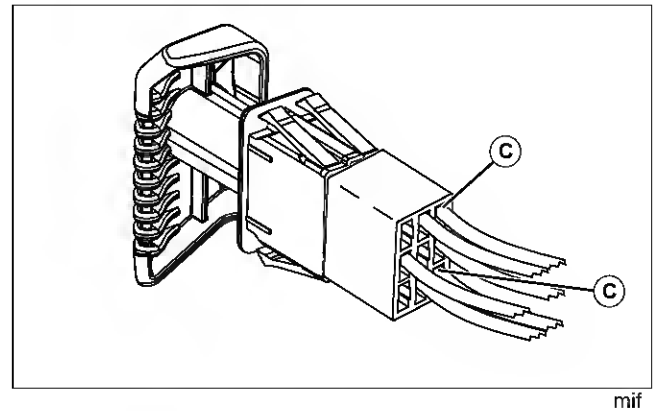
No: Go to next step.



2. Is battery voltage present at the interlock module connector X10 C terminal (B)?

Yes: Check the 370A and 370B Gry wires and connections. If ok, replace the interlock module.

No: Go to next step.



3. Is battery voltage present at the PTO/RIP switch (C)?

Yes: Check the 300 Grn wire and connections. If ok, replace the PTO/RIP switch. Go to next procedure.

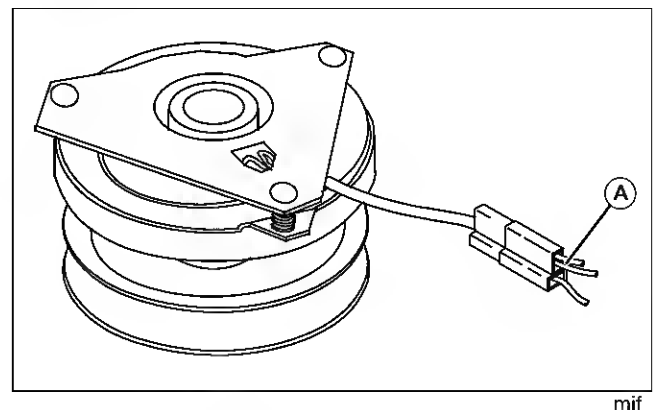
No: Check F4 fuse. Check the 70A, 70B, 71A, 71B, 71C, and 71F Red/Wht wires and connections. If ok, replace key switch.

### Test Procedure B:

#### Test Conditions:

- Brake unlocked
- Reverse pedal depressed (transmission moved to reverse) for each test
- Operator on seat
- Key switch on, engine not running
- PTO/RIP switch on

#### Reverse Shutoff Circuit:

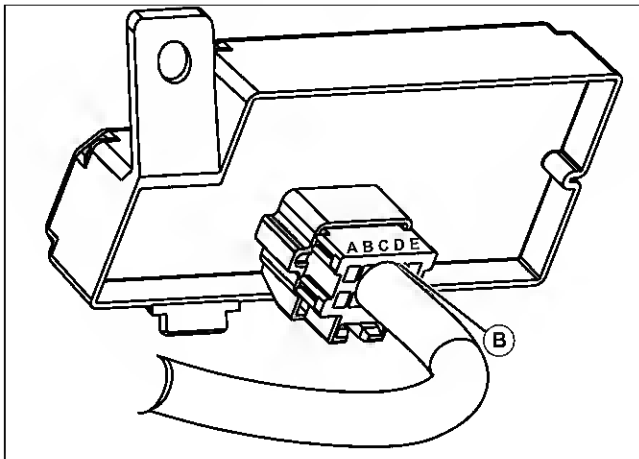


1. Does the battery voltage present at the PTO clutch connector X5 (A) drop to less than 0.5 volts when the reverse pedal is depressed?

Yes: PTO clutch reverse shutoff circuit is functional.

No: Go to next step.

# ELECTRICAL THEORY OF OPERATION (SN -040000)

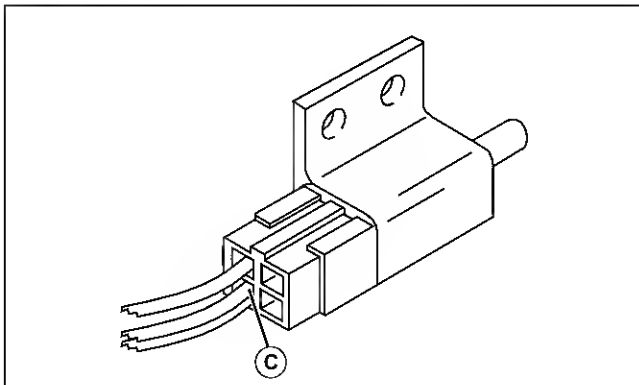


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2. Does battery voltage present at the interlock module connector X10 D terminal (B) drop to less the 0.5 volts when the reverse pedal is depressed?

Yes: Check the 370A and 370B Gry wires and connections for a short to a battery voltage. If ok, replace the interlock module.

No: Go to next step.



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3. Is battery voltage present at the reverse switch (C)?

Yes: Check the 204A and 204B Tan wires and connections. If ok, replace the reverse switch. Go to next procedure.

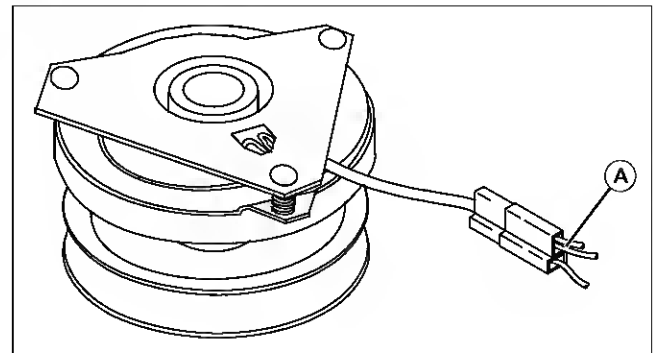
No: Check F4 fuse. Check the 70A, 70B, 71G, and 71H Red/Wht wires and connections. If ok, replace key switch.

## Test Procedure C:

### Test Conditions:

- Brake unlocked
  - Operator on seat
  - Key switch on, engine not running
  - PTO/RIP switch pulled up from on position to momentary position
- then,
- Reverse pedal depressed (transmission moved to reverse) for each test

### Momentary Circuit:

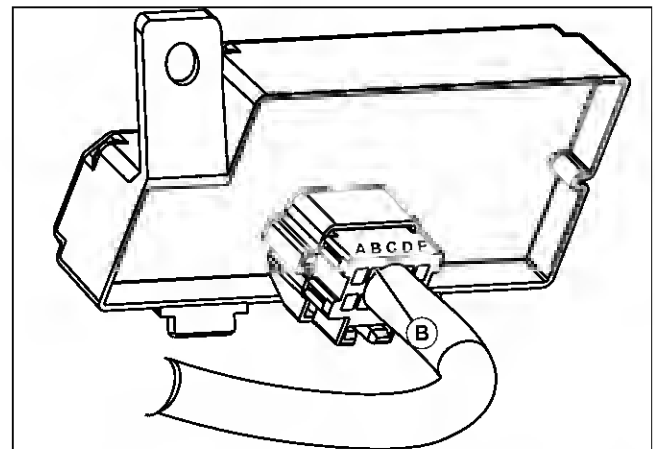


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1. Does the battery voltage remain present at the PTO clutch connector X5 (A) when the PTO/RIP switch is pulled up to the momentary position and then the reverse pedal is depressed?

Yes: PTO clutch momentary circuit is functional.

No: Verify that the PTO/RIP switch is pull-up and held before and until the reverse pedal is depressed. Go to next step.



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2. Is battery voltage present at the interlock module connector X10 B terminal (B) when the PTO/RIP switch is pulled up to the momentary position?

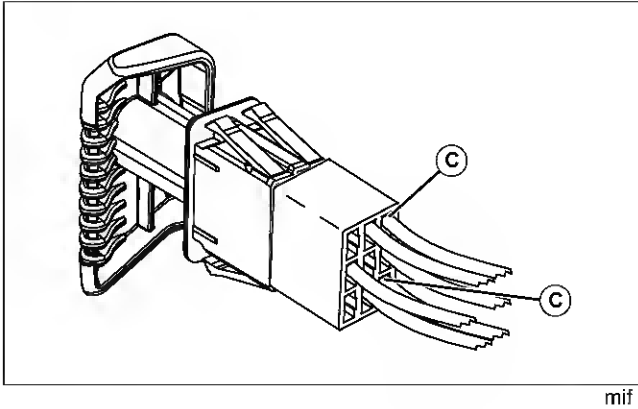


## ELECTRICAL THEORY OF OPERATION (SN -040000)

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Yes: Check the 370A and 370B Gry wires and connections for a short to a battery voltage. If ok, replace the interlock module.

No: Go to next step.



3. Is battery voltage present at the PTO/RIP switch (C)?

Yes: Check the 301 Gry wire and connections. If ok, replace the PTO/RIP switch.

No: Check F4 fuse. Check the 70A, 70B, 71A, 71B, 71C, and 71F Red/Wht wires and connections. If ok, replace key switch.

# ELECTRICAL THEORY OF OPERATION (SN -040000)

## Charging Circuit Operation

### Function:

To maintain battery voltage at 12.4 volts or higher.

### Operating Conditions:

The engine must be running for the charging system to operate.

- Key switch On, engine running
- Operator on seat

or,

- Key switch On, engine running
- Brake locked
- Operator off seat

### Theory of Operation:

The charging system is a permanent magnet and stator design.

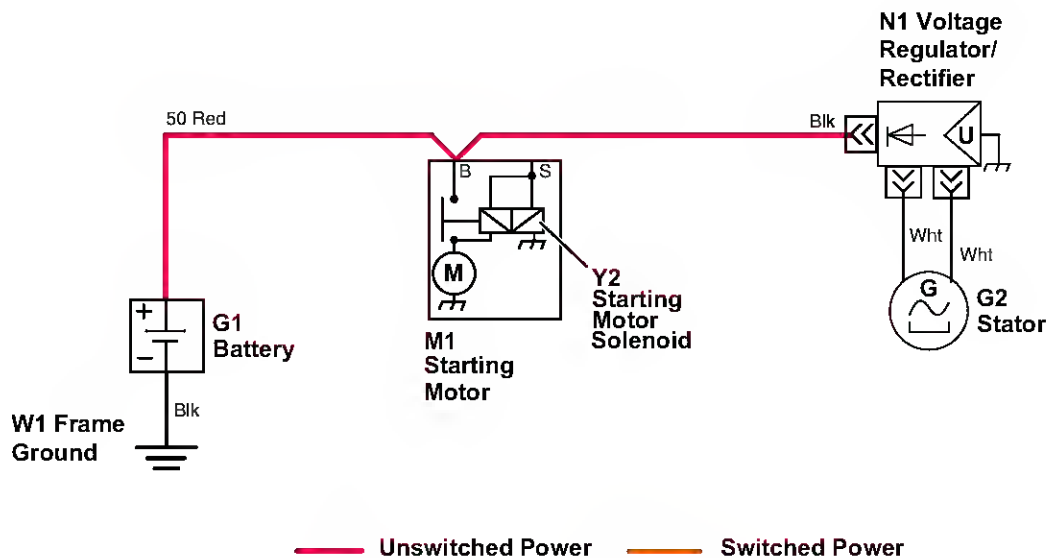
Charging output is controlled by the N1 voltage regulator/rectifier.

With the engine running, current flows from the G2 stator to the N1 voltage regulator/rectifier to the battery positive (+) terminal through the Blk wire to the Y2 starting motor solenoid and finally to the positive battery cable. The circuit allows the voltage regulator/rectifier to charge the battery.

As the flywheel turns, a permanent magnet located in the flywheel induces AC current in the G2 stator windings. The AC current flows to the regulator/rectifier. The regulator/rectifier converts the AC current to DC current needed to charge the battery.

When voltage drops below 14.7 VDC, the voltage regulator/rectifier allows DC current to flow to the battery to charge it. As the battery becomes fully charged, the regulator reduces current flow to the battery.

## Charging Circuit Schematic



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# ELECTRICAL THEORY OF OPERATION (SN -040000)

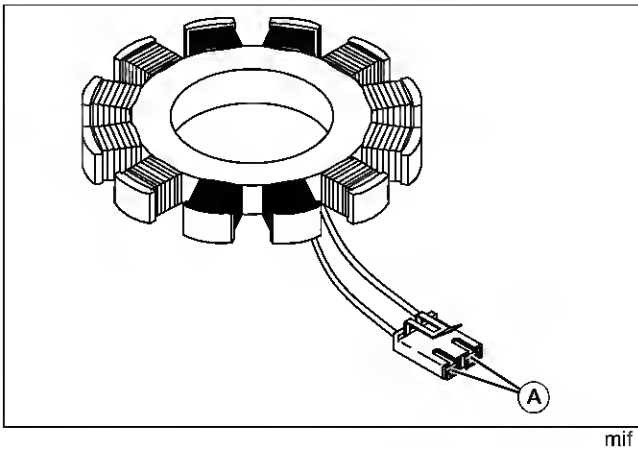
## Charging Circuit Diagnostics

### Test Procedure A:

#### Test Conditions:

- Machine parked safely.
- Park brake locked.
- PTO in off position.
- Battery fully charged.
- Stator connector unplugged.
- Voltmeter set to AC.
- Engine running at full throttle.

#### Charging System - Stator:



1. Is the voltage measured between stator lead(s) approximately 28 volts AC or higher (A)?

Yes: Go to next procedure.

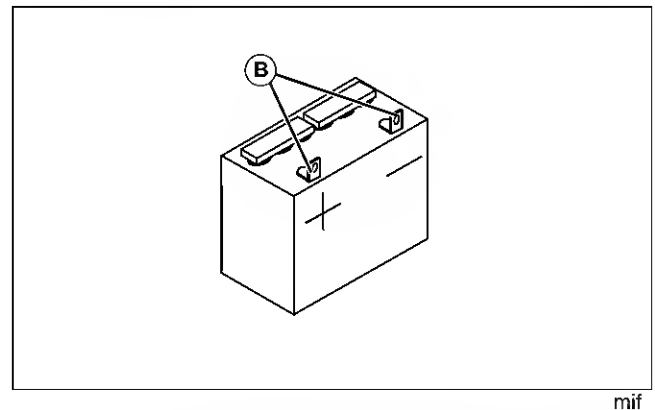
No: If below 28 volts AC, replace stator.

### Test Procedure B

#### Test Conditions:

- Machine parked safely.
- Park brake locked.
- PTO in off position.
- Battery fully charged.
- Stator connected.
- All electrical load sources off, (headlights, accessories).
- Engine running at low idle then to high idle during test.

#### Charging System:



1. Is the voltage across the battery terminals rise from approximately 12.5 VDC to 13.5 VDC or higher when the throttle is moved from low idle to high idle.

Yes: Test complete.

No: Check for poor connections between battery, starting motor solenoid, and voltage regulator/rectifier.

No: Test voltage regulator/rectifier. See "Regulated Voltage Test" on page 345 and other related tests.

## Fuel Shutoff Solenoid Circuit Operation

### Function:

To energized the fuel shutoff solenoid when the proper operating condition are met.

### Operating Conditions:

- Key switch in START or ON
- and,
- Operator ON the seat
- or,
- Brake pedal depressed

### Theory of Operation:

The Y1 fuel shutoff solenoid uses an electromagnetic coil to operate a plunger. The fuel shutoff solenoid plunger stops fuel flow in the carburetor bowl when the solenoid is de-energized. The interlock module provides power to the fuel shutoff solenoid. When the interlock module is de-energized, the fuel shutoff solenoid stops fuel flow at the same time the spark is stopped, helping to prevent backfire at engine shutdown.

With the S4 key switch in the ON or START position, current flows through the 70A and 70B Red/Wht wires to the 7.5 amp F4 fuse. From the F4 fuse current is supplied to the 71 Red/Wht wires. The 71A, 71B, and 71D Red/Wht wires provide operating current to the interlock module. With a properly functioning ground from the 2U, 2B, and 2A Blk wires, the interlock module will be powered on.

At the same time current is supplied to the 71G, 71H, and 71J Red/Wht wires. This will provide current to the brake and seat switches.

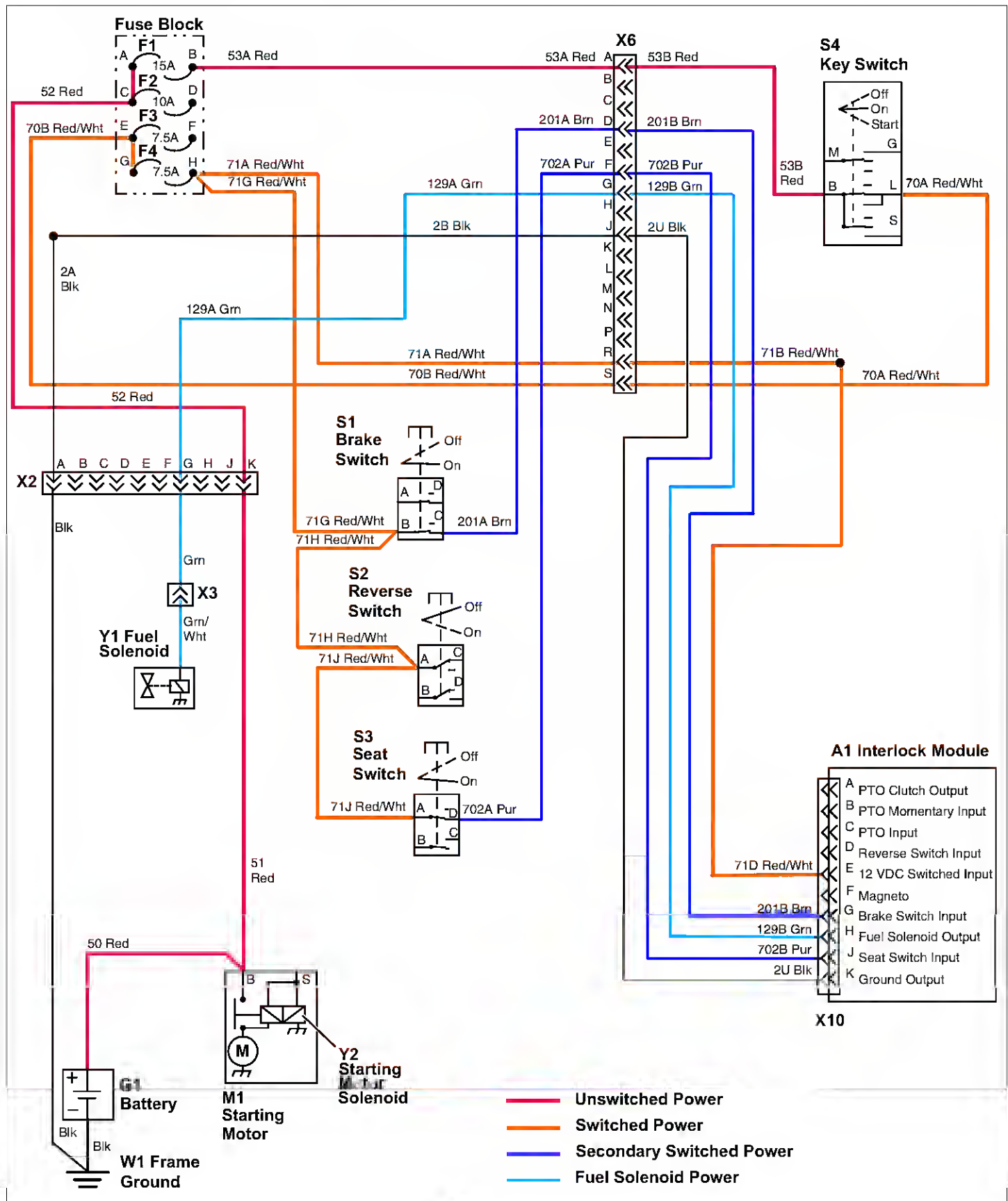
The fuel shutoff solenoid requires that either the brake or the seat switch be closed to provide the input signal to the interlock module so that the module will then provide the output to the fuel shutoff solenoid.

From the seat switch, current is provide across the switch from the 71J Red/Wht wire to the 702A and 702B Pur wires. This provides an input signal to the interlock module which in turn allows the interlock module to provide output current to the fuel shutoff solenoid on the 129B Grn, 129A Grn, and engine harness Grn and Grn/Wht wires. The fuel shutoff solenoid will then be energized to open the plunger an allow fuel to flow in the carburetor bowl.

Alternatively, the brake switch may be used to provide the input signal to the interlock module. From the brake switch (pedal depressed), current is provide across the switch from the 71G Red/Wht wire to the 201A and 201B Brn wires. This provides an input signal to the interlock module which in turn allows the interlock module to provide output current to the fuel shutoff solenoid on the 129B Grn, 129A Grn, and engine harness Grn and Grn/Wht wires. The fuel shutoff solenoid will then be energized to open the plunger an allow fuel to flow in the carburetor bowl.

# ELECTRICAL THEORY OF OPERATION (SN -040000)

## Fuel Shutoff Solenoid Circuit Schematic



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# ELECTRICAL THEORY OF OPERATION (SN -040000)

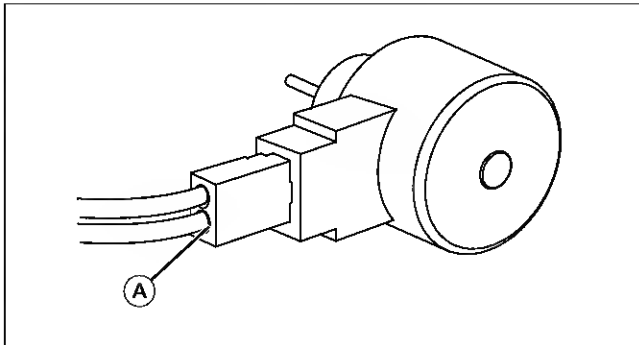
## Fuel Shutoff Solenoid Circuit Diagnostics

### Test Procedure A:

#### Test Conditions:

- Brake locked
- PTO OFF
- Key switch on, engine not running
- Operator off seat
- Transmission in neutral

### Fuel Shutoff Solenoid - Brake Circuit:

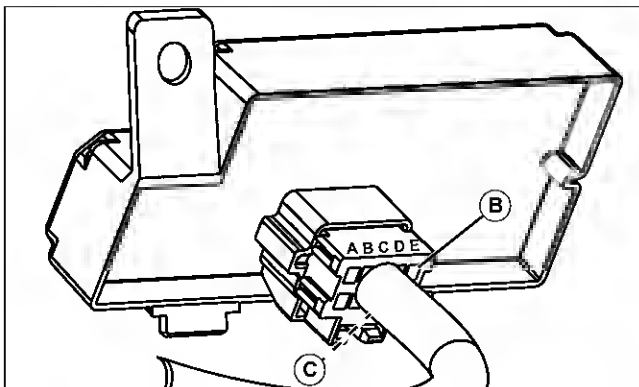


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1. Is battery voltage present at the fuel shutoff solenoid Grn/Wht wire (A)?

Yes: Fuel shutoff circuit is functioning properly. Test the fuel shutoff solenoid. See "Fuel Shutoff Solenoid Test" on page 352. Go to next procedure.

No: Go to next step.



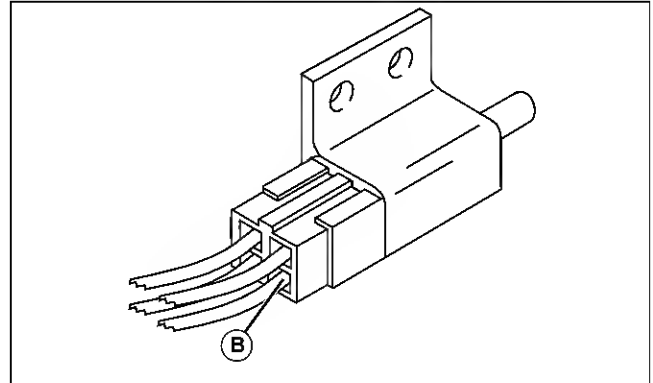
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2. Is battery voltage present at the E and G terminals of the X10 connector to the interlock module (B and C)?

Yes: Check the 129B Grn, 129A Grn, Grn, and Grn/Wht wires and connections. If ok, replace the interlock module.

No: If no voltage at terminal E, See "Switched Power:" on page 237.

No: If no voltage at terminal G, Go to next step.



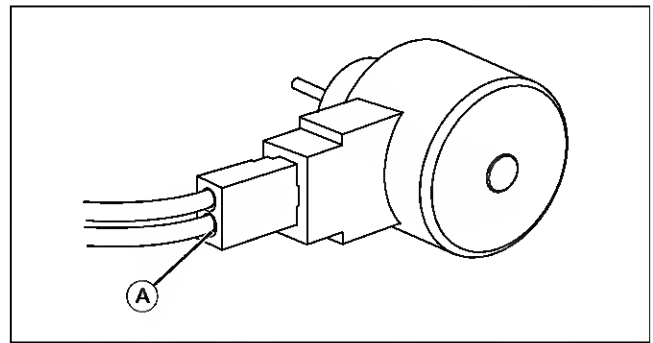
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3. Is battery voltage present at the brake switch (B)?

Yes: Check the 201A and 201B Brn wires and connections. If ok, replace the brake switch.

No: Check F3 fuse. Check the 70A, 70B, and 71G Red/Wht wires and connections. If ok, See "Switched Power:" on page 237.

### Fuel Shutoff Solenoid - Seat Circuit:

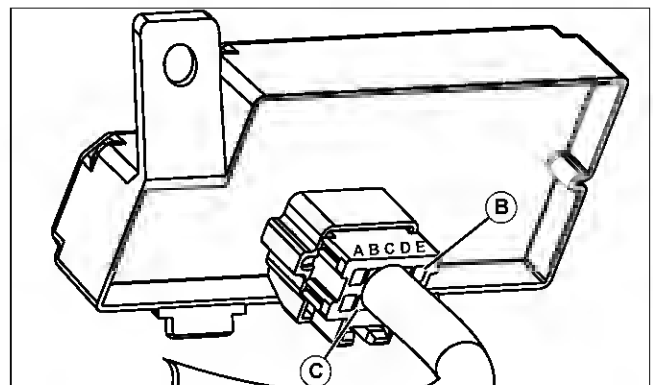


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1. Is battery voltage present at the fuel shutoff solenoid Grn/Wht wire (A)?

Yes: Fuel shutoff circuit is functioning properly. Test the fuel shutoff solenoid. See "Fuel Shutoff Solenoid Test" on page 352. Go to next procedure.

No: Go to next step.



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## ELECTRICAL THEORY OF OPERATION (SN -040000)

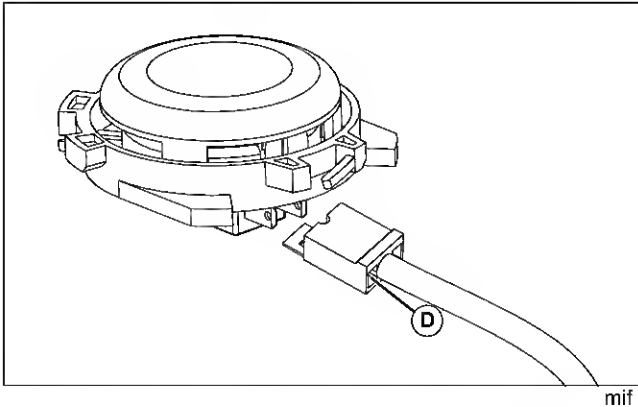
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2. Is battery voltage present at the E and J terminals of the X10 connector to the interlock module (B and C)?

Yes: Check the 129B Grn, 129A Grn, Grn, and Grn/Wht wires and connections. If ok, replace the interlock module.

No: If no voltage at terminal E, See "Switched Power:" on page 237.

No: If no voltage at terminal J, Go to next step.



3. Is battery voltage present at the seat switch (D)?

Yes: Check the 702A and 702B Pur wires and connections. If ok, replace the seat switch.

No: Check F3 fuse. Check the 70A, 70B, 71G, 71H, and 71J Red/Wht wires and connections. If ok, See "Switched Power:" on page 237.

## Headlight Circuit Operation

### Function:

To provide power to the headlights for illumination if desired by the operator.

### Operating Conditions:

- Key switch in ON position
- Headlight switch in ON position

### Theory of Operation:

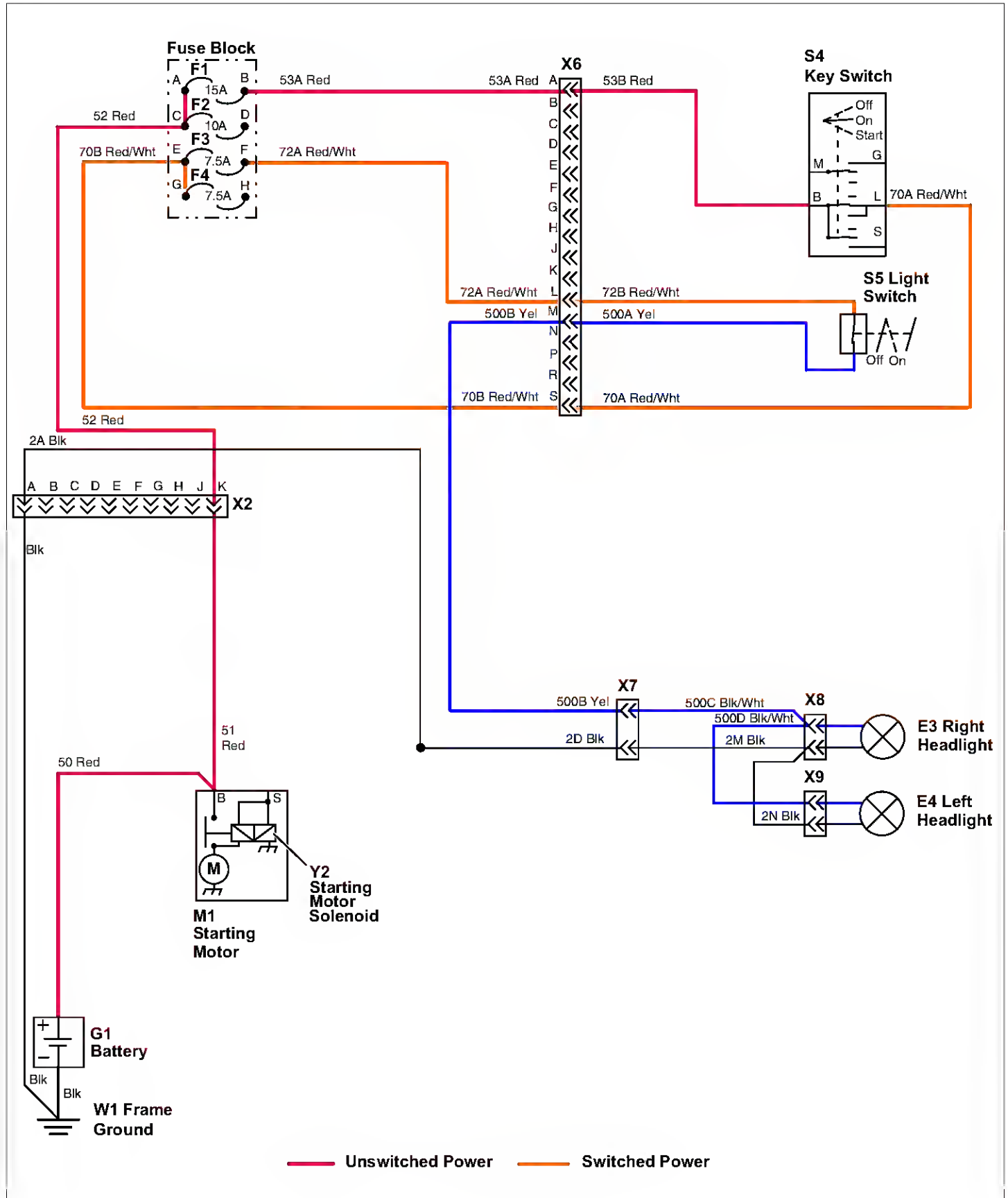
With the S4 key switch in the ON position, current flows through the 70A and 70B Red/Wht wires to the 7.5 amp F3 fuse. From the F3 fuse current is supplied to the 72A and 72B Red/Wht wires to the light switch. With the light switch in the on position current flows through the light switch and on to the E3 and E4 headlights on the 500A, 500B Yel, 500C and 500D Blk/Wht wires.

The ground circuit provides a path to ground for the headlights on the 2N, 2M, 2D, and 2A Blk wires to the W1 frame ground.



# ELECTRICAL THEORY OF OPERATION (SN -040000)

## Headlight Circuit Schematic



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## Headlight Circuit Diagnostics

### Test Procedure A:

#### Test Conditions:

- Key switch on
- Light switch on

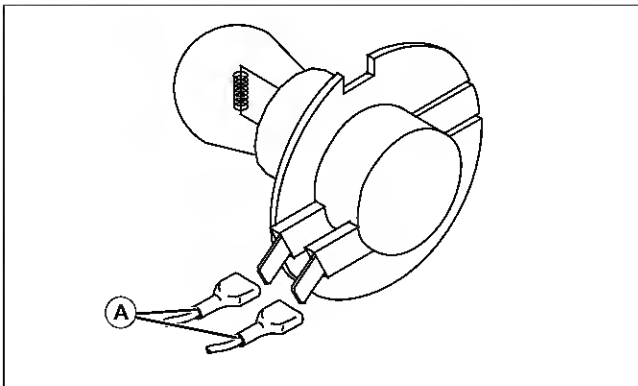
#### Headlights:

1. Are both headlights illuminated?

Yes: Circuit is functioning properly.

No: Test the bulb of the light(s) that are not illuminated.

Go to next step.

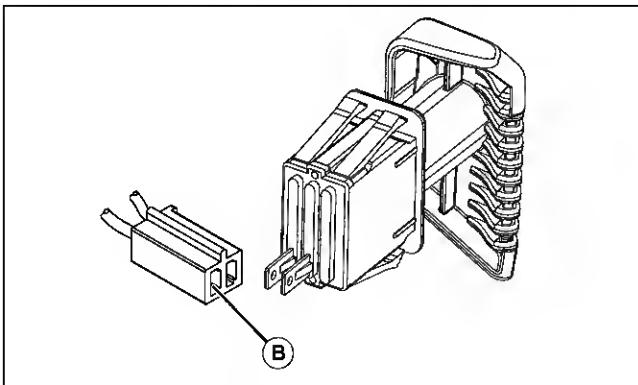


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2. Disconnect the harness from the headlights. Is battery voltage present across the wiring harness connector terminals (A) for each headlight?

Yes: Replace the bulb(s) not illuminated.

No: Check F4 fuse. Check the 500A, 500B Yel, 500C and 500D Blk/Wht wires and connections.



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3. Is battery voltage present at the light switch (B)?

Yes: Replace the light switch.

No: Check F3 fuse. Check the 70A, 70B, 72A, and 72B Red/Wht wires and connections. If ok, replace key switch.

## Accessories Circuit Operation

### Function:

To provide power to the hour meter and power port if equipped.

### Operating Conditions - Hour Meter:

- Key switch On

### Theory of Operation - Hour Meter:

The hour meter uses switch power to operate. With the S4 key switch in the ON position, current flows through the 70A and 70B Red/Wht wires to the 7.5 amp F4 fuse. From the F4 fuse current is supplied to the 71 Red/Wht wires. The 71A, 71B, and 71E Red/Wht wires provide operating current to the hour meter. With a properly functioning ground from the 2V, 2Y, and 2A Blk wires, the hour meter will be powered on.

### Operating Conditions - Power Port:

- Fully charged and properly connected battery

### Theory of Operation - Power Port:

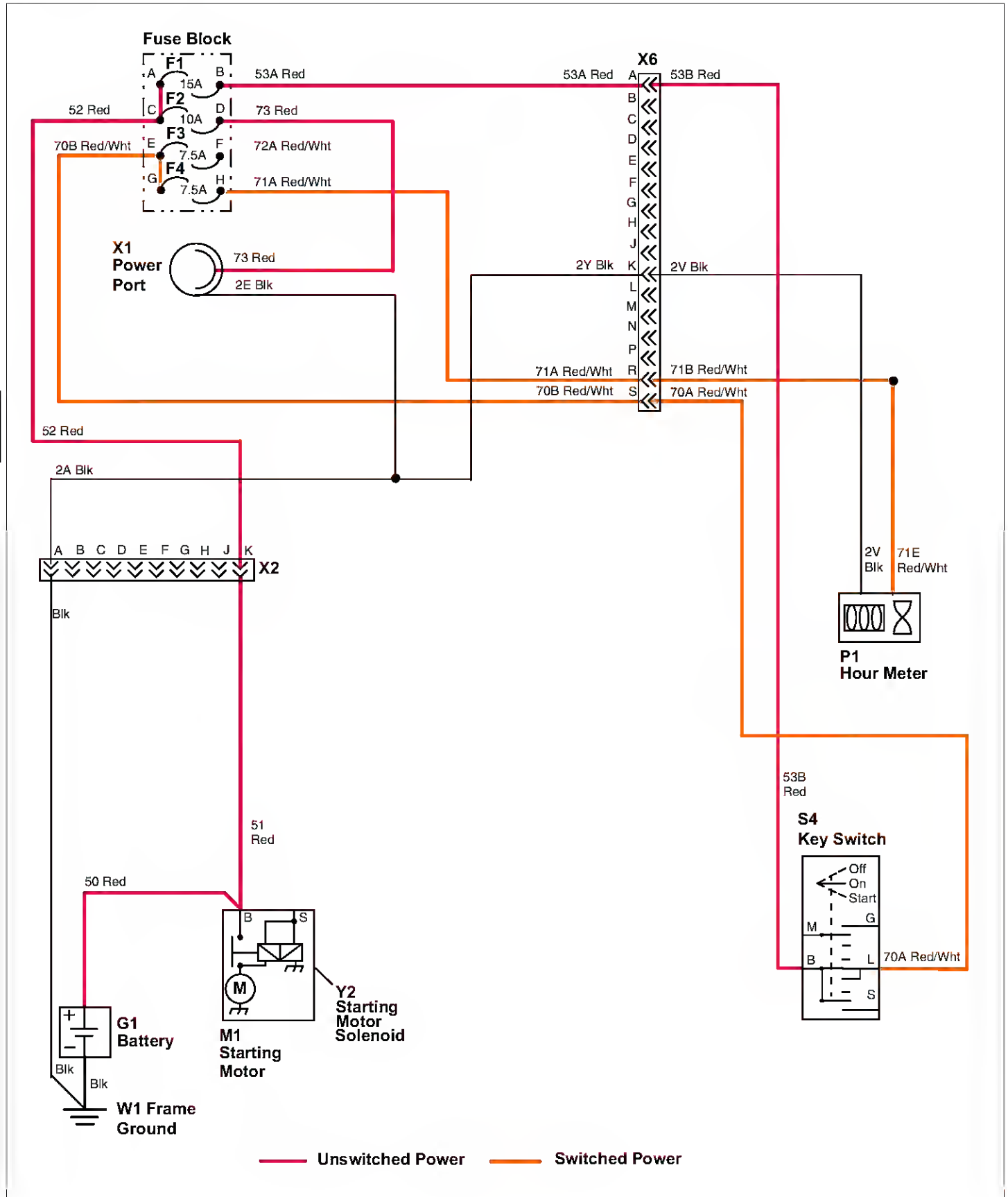
The power port uses Unswitched power to supply power to operator connected accessories.

The positive battery cable connects the battery to the starting motor. The 51 and 52 Red wires supply voltage to the F2 fuse. The F2 fuse protect the power port circuit. The battery cables and the starting motor tie point connections must be good for the machine's electrical system to work properly.

The ground circuit provides a path to ground for the power port on the 2E and 2A Blk wires to the W1 frame ground.

# ELECTRICAL THEORY OF OPERATION (SN -040000)

## Accessories Circuit Schematic



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# ELECTRICAL THEORY OF OPERATION (SN -040000)

## Accessories Circuit Diagnostics

### Test Procedure - Hour Meter:

#### Test Conditions:

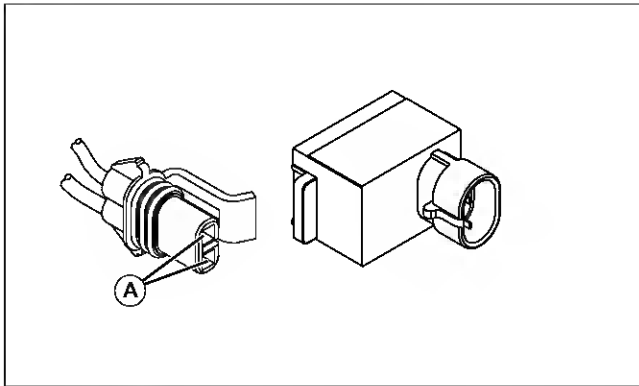
- Key switch on

#### Hour Meter:

1. Does the hour meter power up showing the hours of operation when the key switch is turned on?

Yes: Circuit is functioning properly.

No: Go to next step.



2. Disconnect the harness from the hour meter. Is battery voltage present across the wiring harness connector terminals (A)?

Yes: Replace the hour meter.

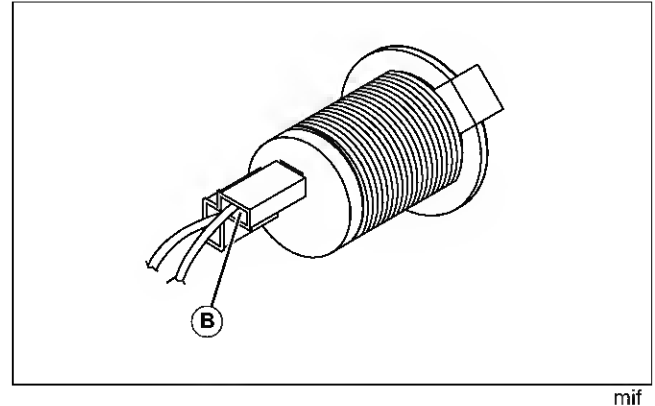
No: Check F4 fuse. Check the 70A, 70B, 71A, 71B, and 71E Red/Wht wires and connections. If ok, replace key switch. See "Power Circuit Operation" on page 234.

### Test Procedure - Power Port:

#### Test Conditions:

- Fully charged and properly connected battery

#### Power Port:



1. Is battery voltage present at the power port (B)?

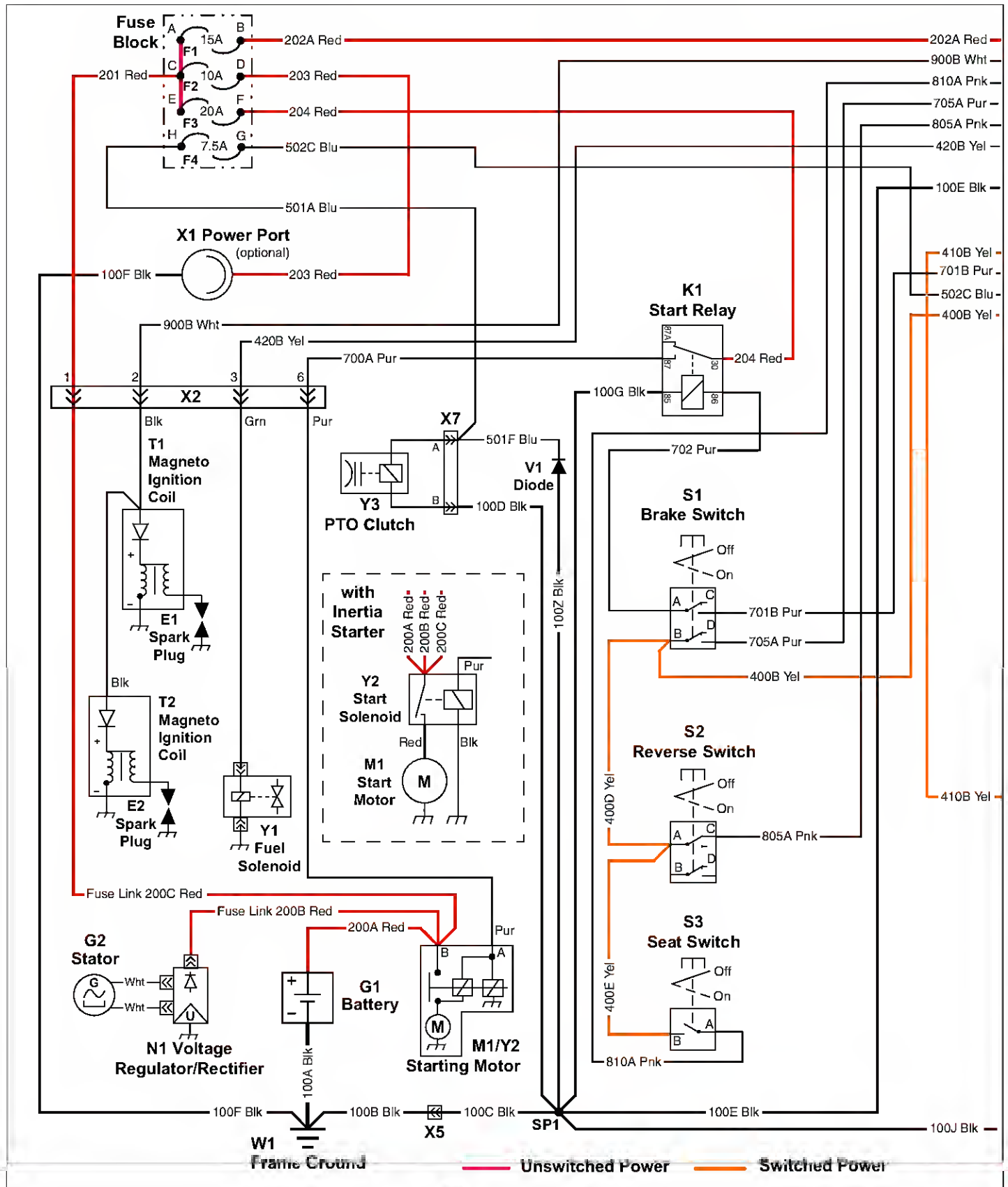
Yes: Circuit is functioning properly.

No: Test the F2 10 amp fuse. Check the 51, 52, and 73 Red wires and connections. If ok, replace the power port connector.

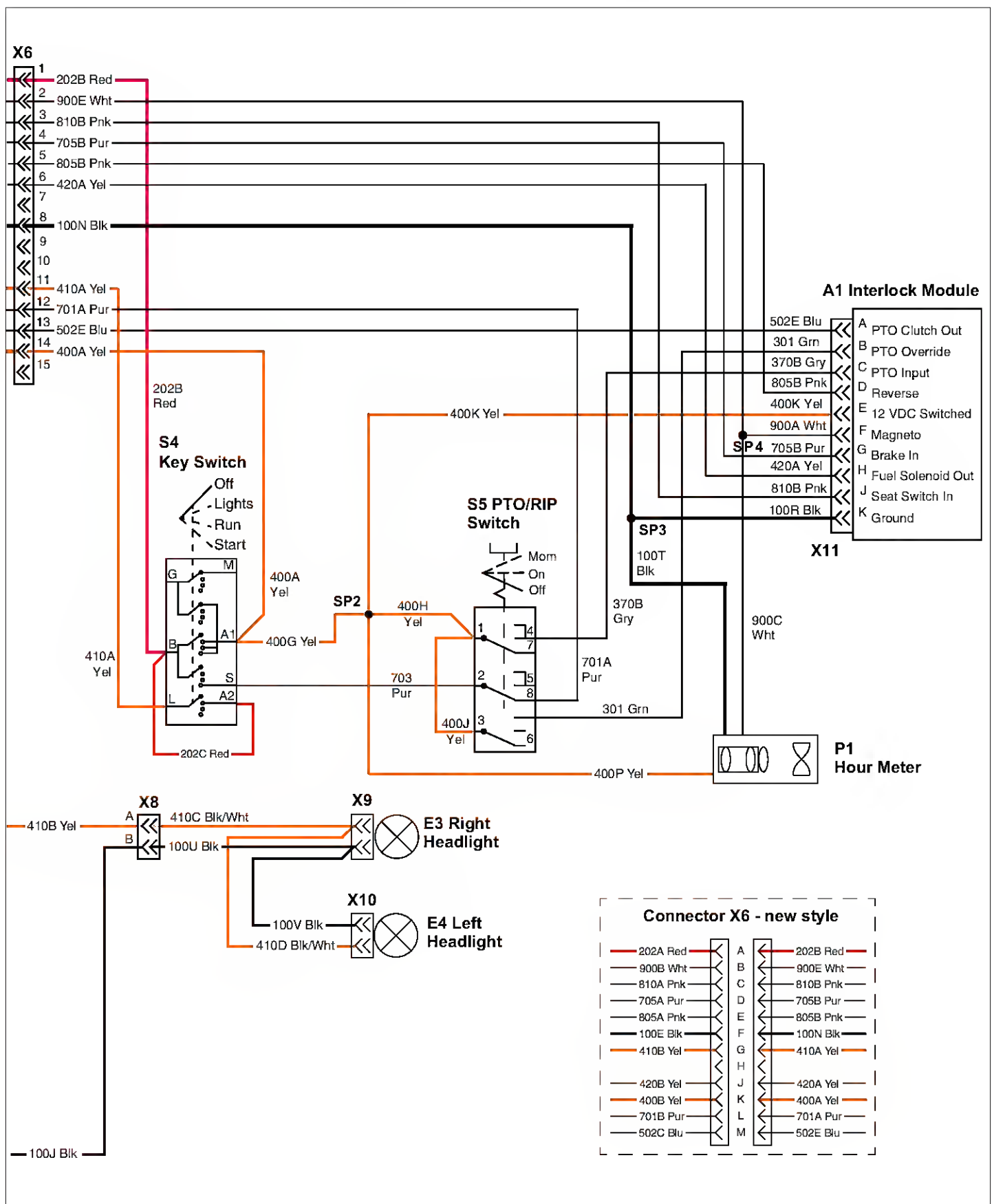
# ELECTRICAL SCHEMATICS AND HARNESSES (SN 040001-)

## Schematics and Harnesses (SN 040001-)

## Main Wiring Schematic



## ELECTRICAL SCHEMATICS AND HARNESSES (SN 040001-)



# ELECTRICAL SCHEMATICS AND HARNESSES (SN 040001-)

---

## Schematic and Wiring Harness Legend

A1 - Interlock Module  
B1 - Engine Oil Pressure Switch (not used)  
B2 - Temperature Switch (not used)  
E1 - Spark Plug  
E2 - Spark Plug  
E3 - Right Headlight  
E4 - Left Headlight  
F1 - Fuse 15A  
F2 - Fuse 10A  
F3 - Fuse 20A  
F4 - Fuse 7.5A  
G1 - Battery  
G2 - Stator  
K1 - Start Relay  
M1 - Starting Motor  
N1 - Voltage Regulator/Rectifier  
P1 - Hour Meter  
S1 - Brake Switch  
S2 - Reverse Switch  
S3 - Seat Switch  
S4 - Key Switch  
S5 - PTO/RIP Switch  
T1 - Magneto Ignition Coil  
T2 - Magneto Ignition Coil  
V1 - Diode  
W1 - Battery/Frame Ground  
Y1 - Fuel Shutoff Solenoid  
Y2 - Starting Motor Solenoid  
Y3 - PTO Clutch

## Connectors:

X1 - Power Port (optional)  
X2 - Main Wiring Harness to Engine  
X5 - Main Wiring Harness to W1 Ground  
X6 - Main Wiring Harness to Control Panel Wiring Harness  
X7 - Main Wiring Harness to PTO Clutch  
X8 - Main Wiring Harness to Headlight Wiring Harness  
X9 - Right Headlight  
X10 - Left Headlight  
X11 - Control Panel Wiring Harness to Interlock Module

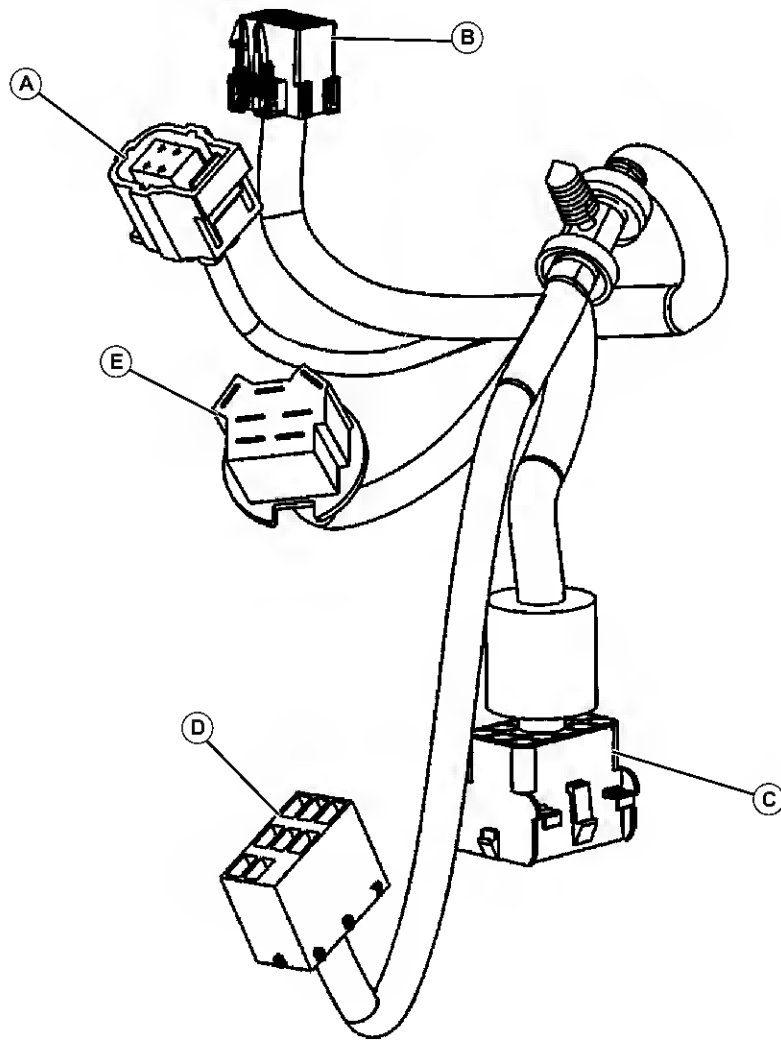
## Wiring Harnesses:

W1 - Main Wiring Harness  
W2 - Engine Wiring Harness  
W3 - Control Panel Wiring Harness  
W4 - Headlight Wiring Harness  
W5 - Power Port Wiring Harness (option)





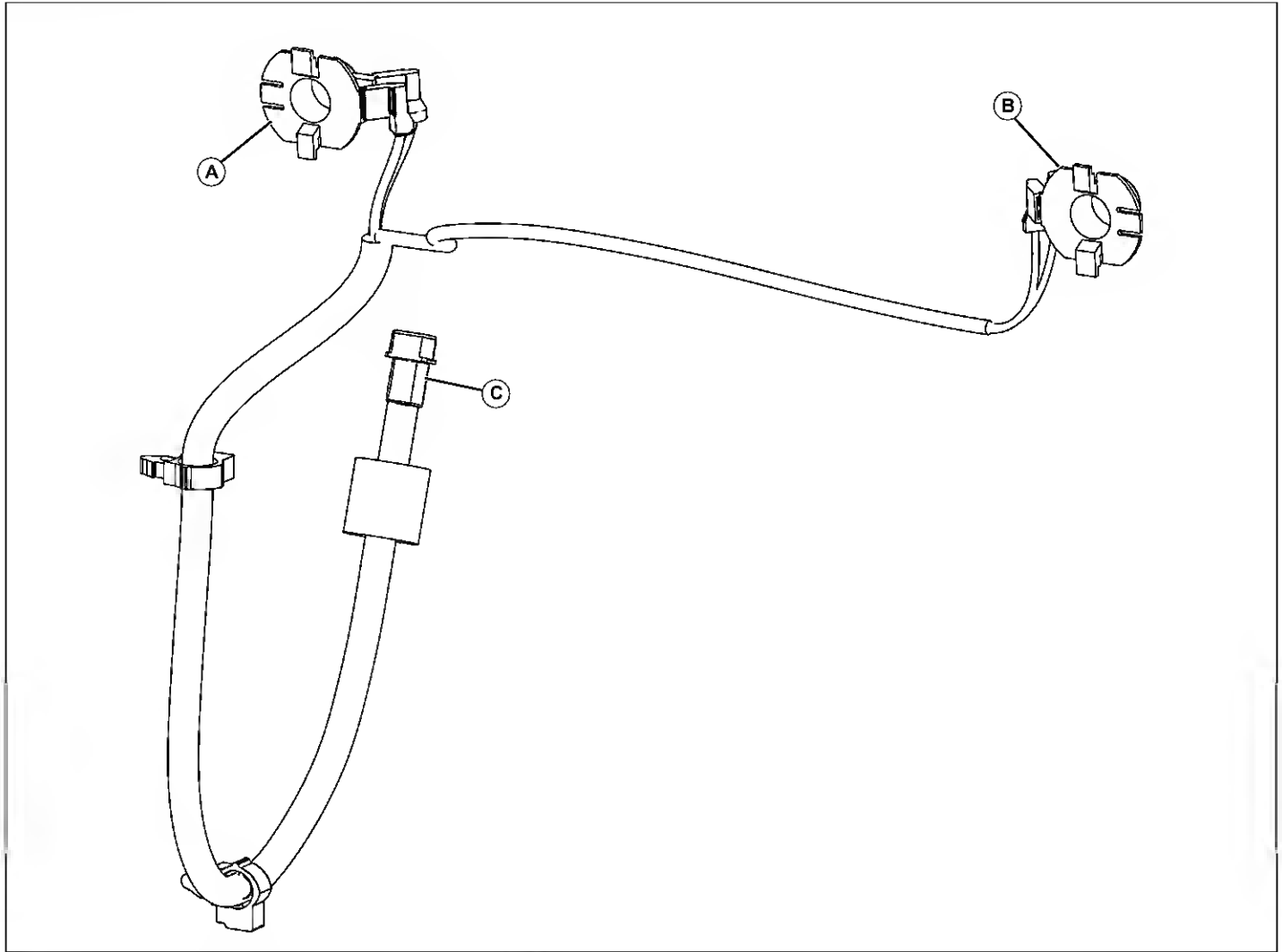
## W3 Control Panel Wiring Harness



MX37972

- A- P1 Hour Meter
- B- X11 to A1 Interlock Module
- C- X6 to W1 Main Wiring Harness
- D- S5 PTO/RIP Switch
- E- S4 Key Switch

## W4 Headlight Wiring Harness

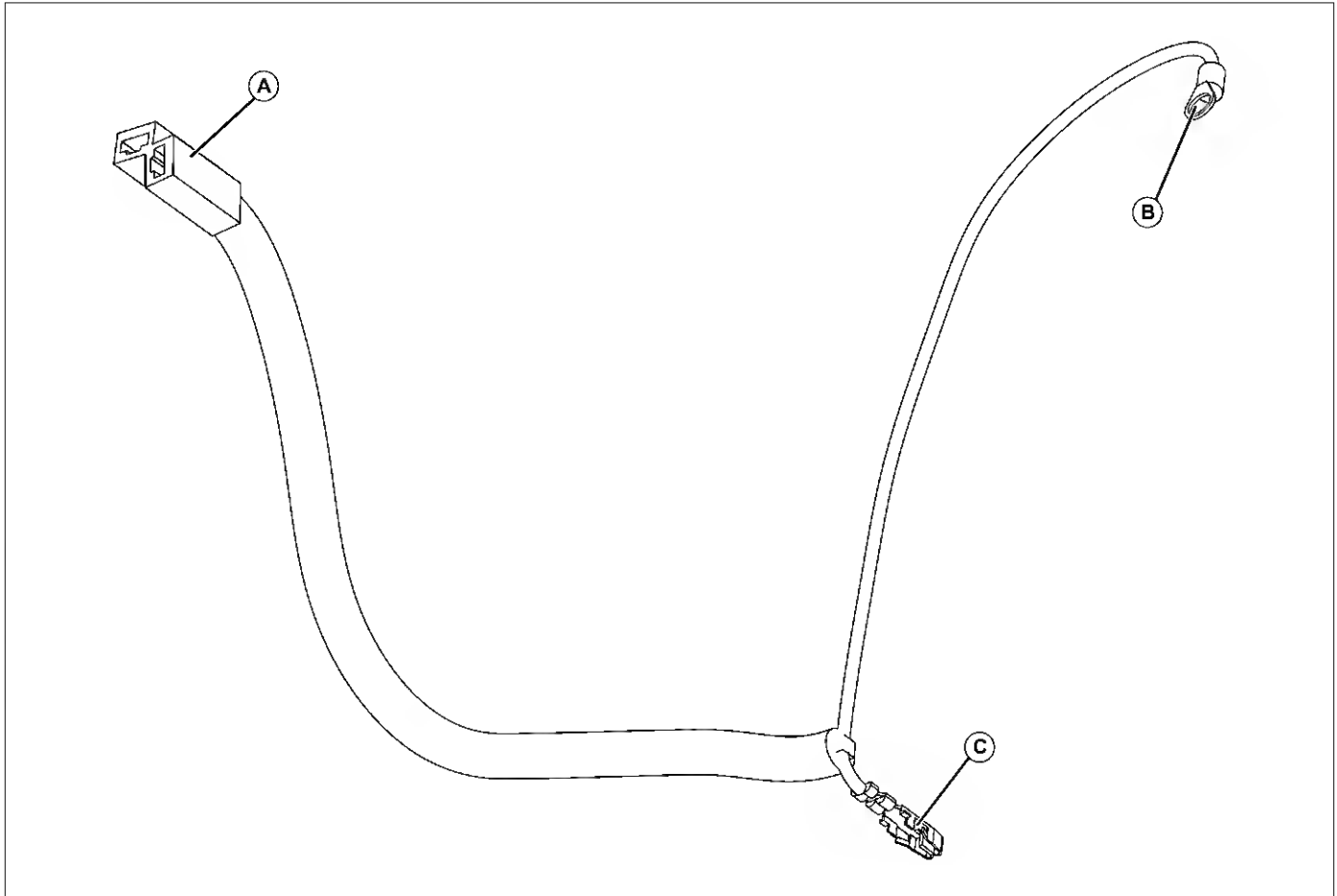


MX37988

- A- X9 to E3 Right Headlight
- B- X10 to E4 Left Headlight
- C- X8 to W1 Main Wiring Harness

# ELECTRICAL SCHEMATICS AND HARNESSES (SN 040001-)

## W5 Power Port Wiring Harness (Option)



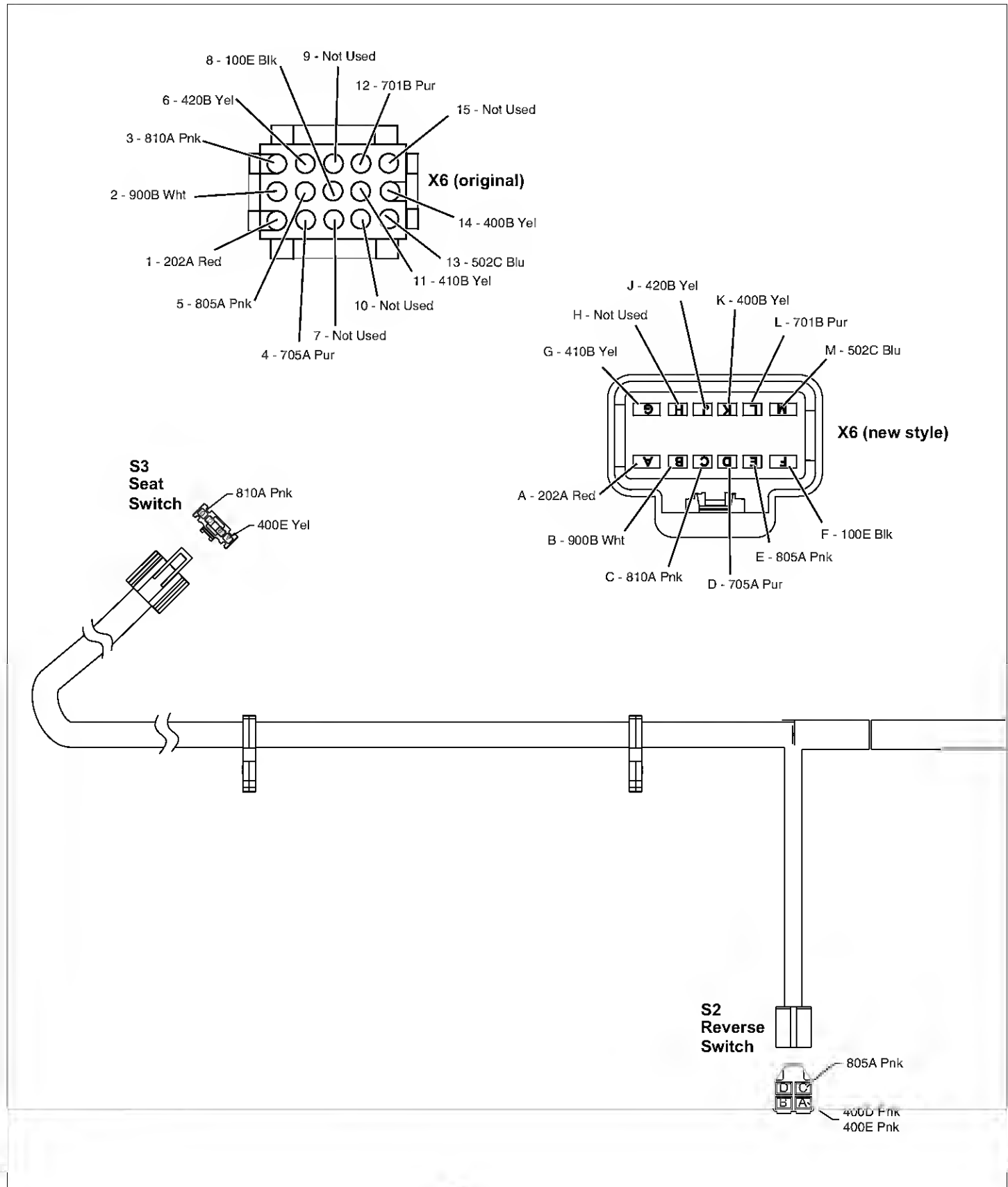
MX38476

- A- X1 to Power Port
- B- To Machine Ground
- C- To F2 Fuse

# ELECTRICAL SCHEMATICS AND HARNESSES (SN 040001-)

## W1 Main Wiring Harness

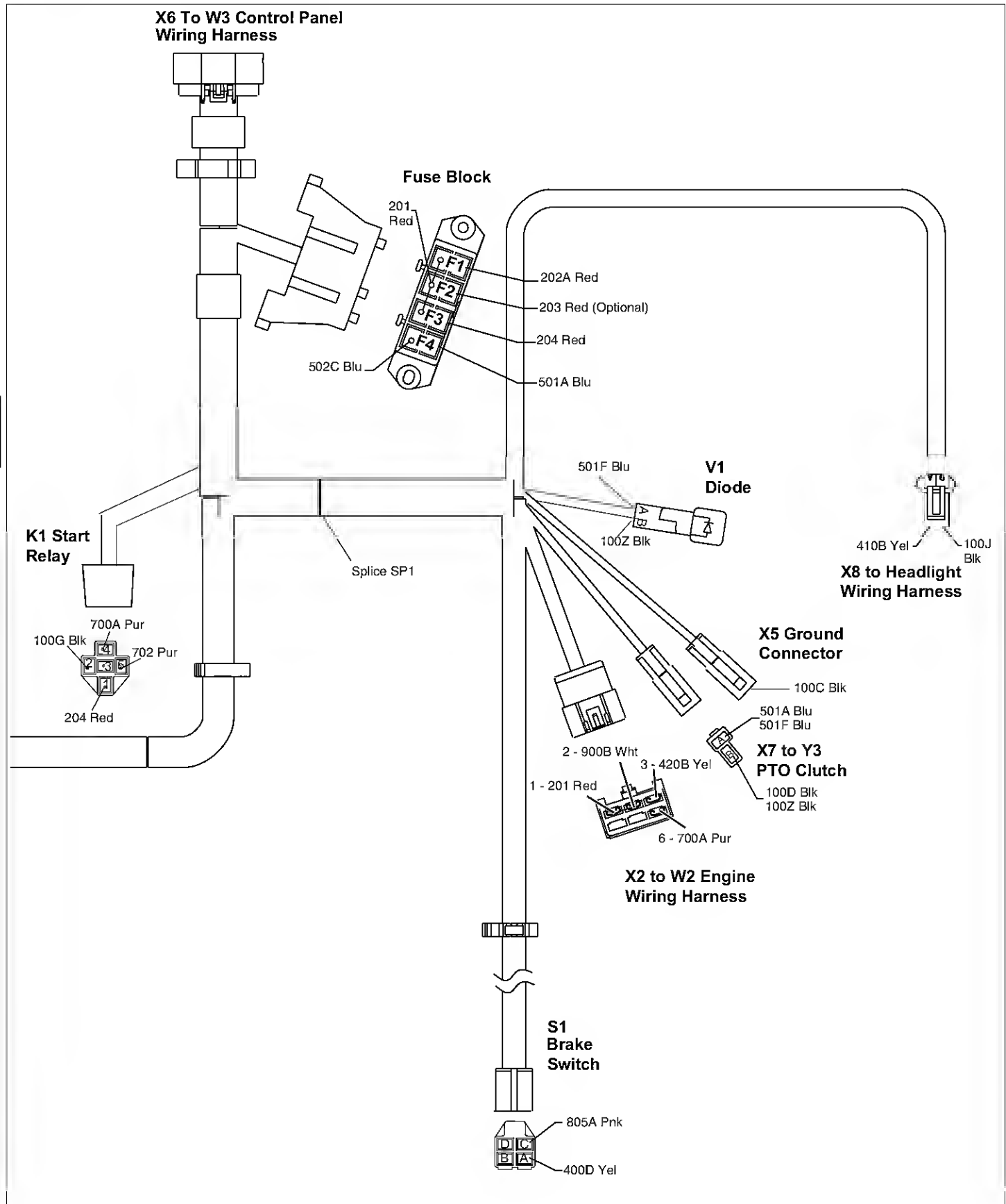
## Harness (1 of 2)



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# ELECTRICAL SCHEMATICS AND HARNESSES (SN 040001-)

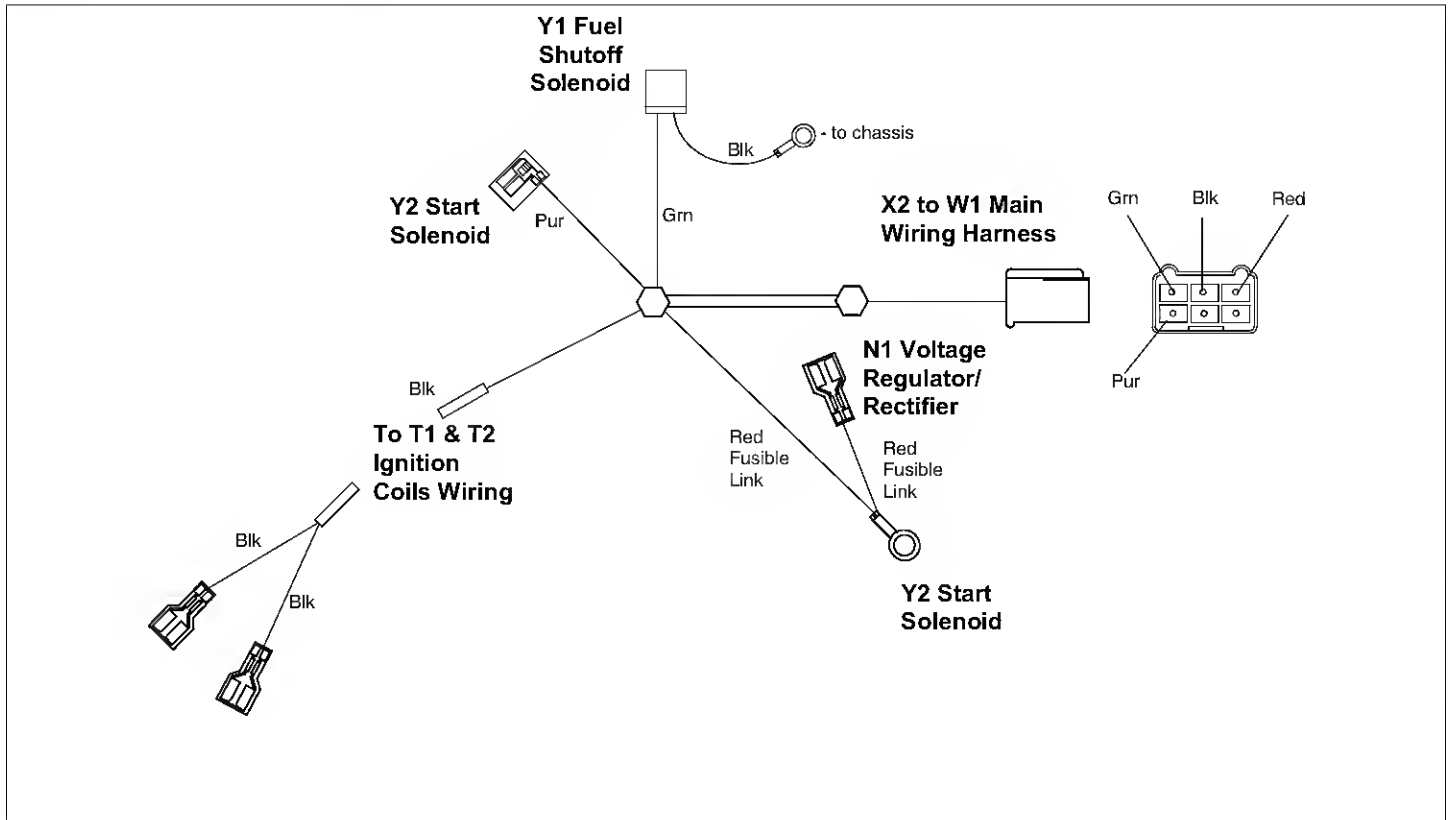
## Harness (2 of 2)



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# ELECTRICAL SCHEMATICS AND HARNESSES (SN 040001-)

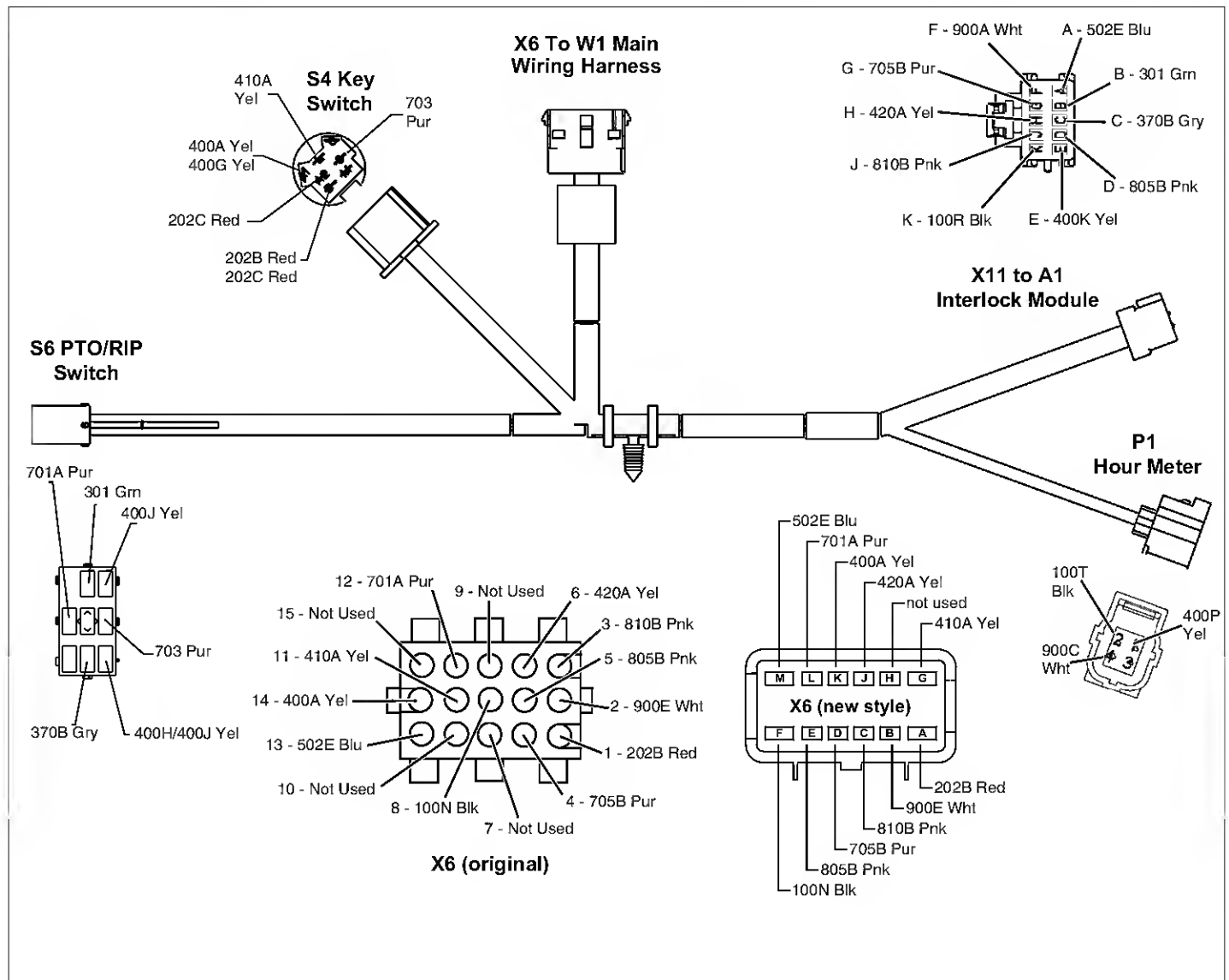
## W2 Engine Wiring Harness



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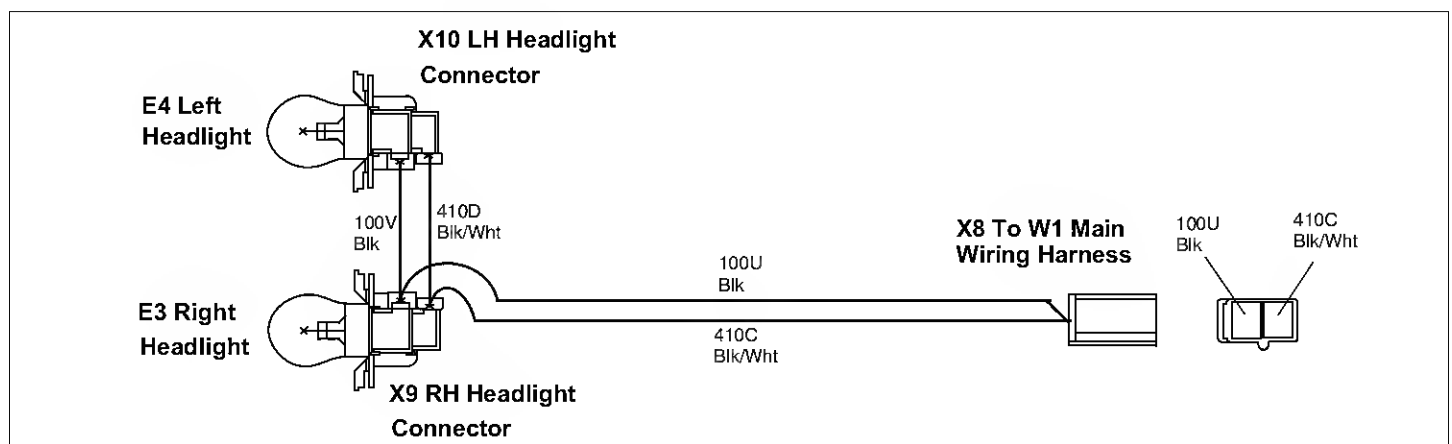
# ELECTRICAL SCHEMATICS AND HARNESSES (SN 040001-)

## W3 Control Panel Wiring Harness



MIF/MX37975/MX38485/MX38486

## W4 Headlight Wiring Harness

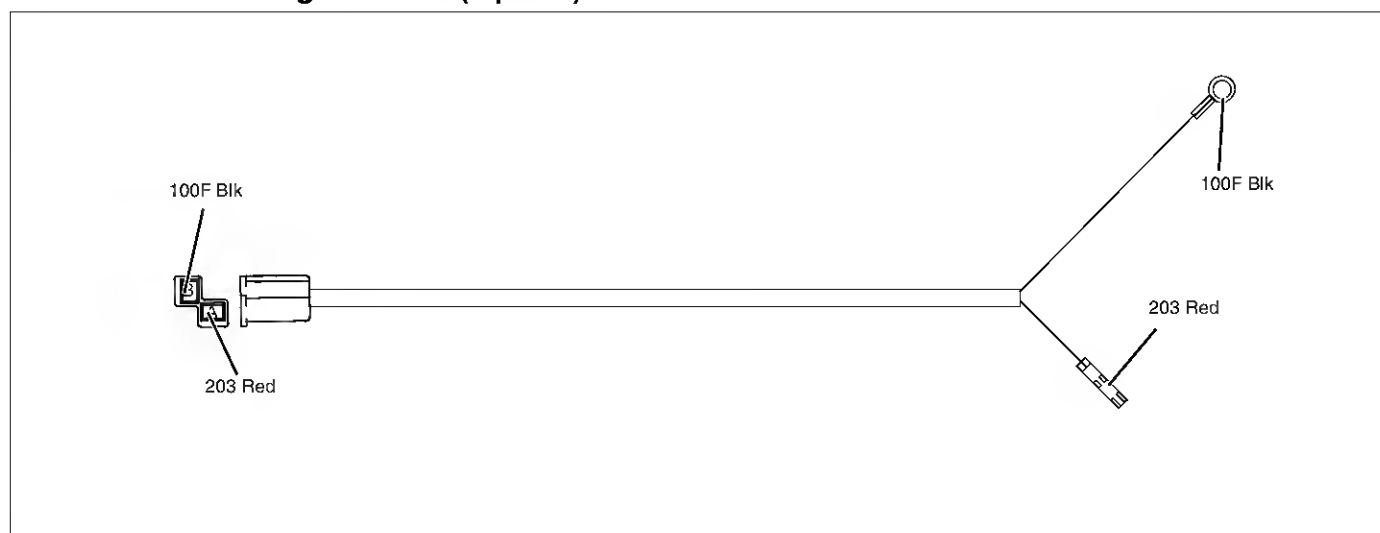


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# ELECTRICAL SCHEMATICS AND HARNESSES (SN 040001-)

## W5 Power Port Wiring Harness (Option)



MIF

Size/No./Color

Wire Connection Points

### W1 Main Wiring Harness Color Codes

1.0 502C Blu

F4, X6

1.0 700A Pur

X2 (Pin 6), K1 (Pin 87)

0.8 701B Pur

S1 (Pin C), X6

0.8 702 Pur

K1 (Pin 86), S1 (Pin A)

0.8 705A Pur

S1 (Pin D), X6

0.8 805A Pnk

S2 (Pin C), X6

0.8 810A Pnk

S3 (Pin B), X6

0.8 900B Wht

X2 (Pin 2), X6

Size/No./Color

Wire Connection Points

3.0 100C Blk

X5, Splice (SP1)

1.0 100D Blk

Splice (SP1), X7 (Pin B)

1.0 100E Blk

Splice (SP1), X6

2.0 100F Blk  
(Optional)

X1, W1 Ground

0.8 100G Blk

K1 (Pin 85), Splice (SP1)

1.0 100J Blk

Splice (SP1), X8 (Pin B)

0.8 100Z Blk

Splice (SP1), V1

5.0 201 Red

X2 (Pin 1), F2 (buss)

2.0 202A Red

F1, X6

2.0 203 Red  
(Optional)

F2, X1

1.0 204 Red

F3, K1 (Pin 30)

2.0 400B Yel

S1 (Pin B), X6

0.8 400D Yel

S1 (Pin B), S2 (Pin B)

0.8 400E Yel

S2 (Pin A), S3 (Pin A)

1.0 410B Yel

X6, X8 (Pin A)

0.8 420B Yel

X2 (Pin 3), X6

1.0 501A Blu

F4, X7 (Pin A)

0.8 501F Blu

V1, X7 (Pin A)

# ELECTRICAL SCHEMATICS AND HARNESSSES (SN 040001-)

## W2 Engine Wiring Harness Color Codes

Size/No./Color	Wire Connection Points
13.0 100A Blk	G1, W1 Ground
3.0 100B Blk	W1 Ground, X5
13.0 200A Red	G1, Y2
3.0 200B Red	Y2, N1
3.0 200C Red	Y2, X2
1.0 Grn	Y1, X2
1.0 Blk	(T1 & T2), X2
1.0 Pur	X2, Y2

## Size/No./Color

## Wire Connection Points

0.8 805B Pnk	X6, A1 (Pin D)
0.8 810B Pnk	X6, A1 (Pin J)
0.8 900A Wht	Splice (SP4), A1 (Pin F)
0.8 900C Wht	Splice (SP4), P1 (Pin C)
0.8 900E Wht	X6, Splice (SP4)

## W4 Headlight Wiring Harness Color Codes

Size/No./Color	Wire Connection Points
0.8 100U Blk	X8, X9
0.8 100V Blk	X9, X10
0.8 410C Blk/Wht	X8, X9
0.8 410D Blk/Wht	X9, X10

## W3 Control Panel Wiring Harness Color Codes

Size/No./Color	Wire Connection Points
1.0 100N Blk	X6, Splice (SP3)
1.0 100R Blk	Splice (SP3), A1 (Pin K)
0.8 100T Blk	Splice (SP3), P1 (Pin B)
2.0 202B Red	X6, S4 (Pin B)
1.0 202C Red	S4 (Pin B), S4 (Pin A2)
0.8 301 Grn	S5 (Pin 6), A1 (Pin B)
0.8 370B Gry	S5 (Pin 4), A1 (Pin C)
2.0 400A Yel	X6, S4 (Pin A1)
1.0 400G Yel	S4 (Pin A2), Splice (SP2)
1.0 400H Yel	Splice (SP2), S5 (Pin 1)
1.0 400J Yel	S5 (Pin 1), S5 (Pin 3)
1.0 400K Yel	Splice (SP2), A1 (Pin E)
1.0 400P Yel	Splice (SP2), P1 (Pin A)
1.0 410A Yel	X6, S4 (Pin L)
0.8 420A Yel	X6, A1 (Pin H)
0.8 502E Blu	X6, A1 (Pin A)
0.8 701A Pur	X6, S5 (Pin 8)
1.0 703 Pur	S4 (Pin S), S5 (Pin 2)
0.8 705B Pur	X6, A1 (Pin G)

# ELECTRICAL THEORY OF OPERATION (SN 040001-)

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## Theory of Operation (SN 040001-)

### Power Circuit Operation

#### Function:

To provide unswitched and switched power to the primary electrical components whenever the battery is properly connected. The power circuits are divided among the unswitched power circuit, switched power circuits (key switch in on position), and secondary power circuits. The secondary power circuit is energized when switched power is supplied to the A1 interlock module providing current to the secondary circuit. The secondary power circuit will not be energized if the A1 interlock module fails.

#### Operating Conditions, Unswitched Circuits:

Voltage must be present at the following components with the key switch in the off position.

- G1 battery positive terminal
- N1 voltage regulator/rectifier
- M1 starting motor - B terminal
- F1, F2 and F3 fuses
- S4 key switch - terminals B and A2
- X1 power port (optional)
- K1 start relay - terminal 30

The positive battery cable connects the battery to the starting motor, where it becomes the 12 volt DC tie point for the rest of the electrical system. The 200B Red wire is a fuse link; it protects the N1 regulator. The 200C Red fuse link provides initial protection for all other power circuits. From there, the 201 Red wire supply voltage the F1, F2 and F3 fuses. The F1 fuse protects the circuit to the key switch, while the F2 fuse protects the power port circuit. The F3 fuse protects the K1 start relay. The battery cables and connections must be good for the machine's electrical system to work properly. Proper starting motor operation depends on the battery cables to carry high current. The ground cable connection is equally as important as the positive cable connection in maintaining electrical system integrity.

#### Operating Conditions, Switched Circuits:

With the key switch in on position, PTO/RIP switch off, brake unlocked, transmission in neutral, and operator off the seat, switched voltage should be present at the following components:

- S4 key switch - terminals L (lights on position), A1 and A2
- S1 brake switch - 400B and 400D Yel wire
- S2 reverse switch - 400D and 400E Yel wires

- S3 seat switch - 400E Yel wire
- A1 interlock module - terminal E, 400K Yel wire
- A1 interlock module - terminal D, 805B Pnk wire
- S6 PTO/RIP switch - 400H and 400J Yel wires
- P1 hour meter - 400P Yel wire

With power now available at various locations on the machine, the electrical system is ready to perform the different functions of starting and running the engine, PTO clutch, system interlocks and the headlights.

The ground circuit is equally important as the power circuit connections. Proper systems operation depends on good wires and connections in order to carry the current needed to operate the various components.

#### Operating Conditions, Secondary Switched Circuits:

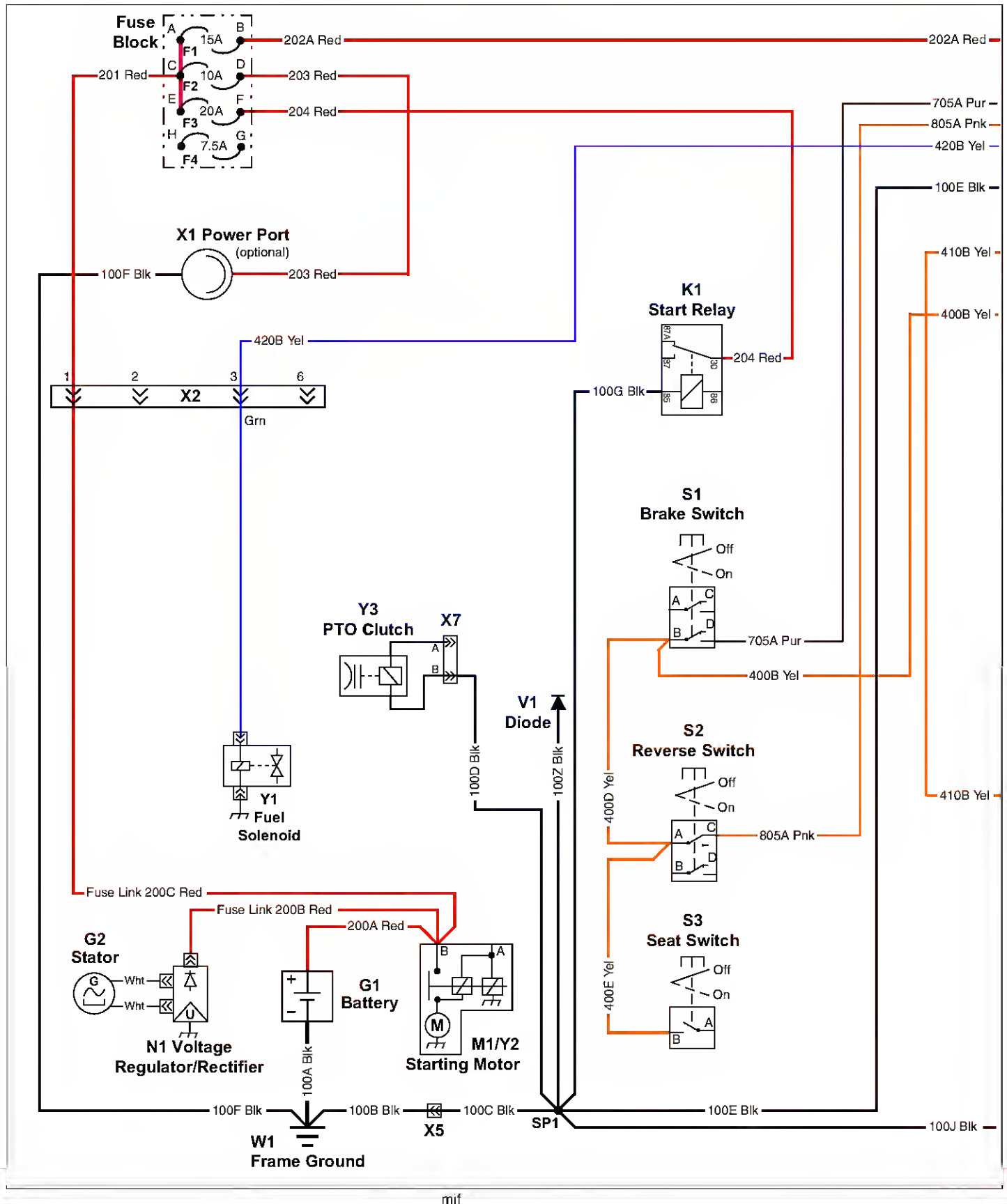
Secondary switched voltage must be present at the following components during the following conditions: Key switch in on position, transmission in neutral, PTO/RIP in off position, brake unlocked, and operator off seat:

- Y1 fuel shutoff solenoid - Grn (420A/420B Yel wires on main and control panel harnesses)

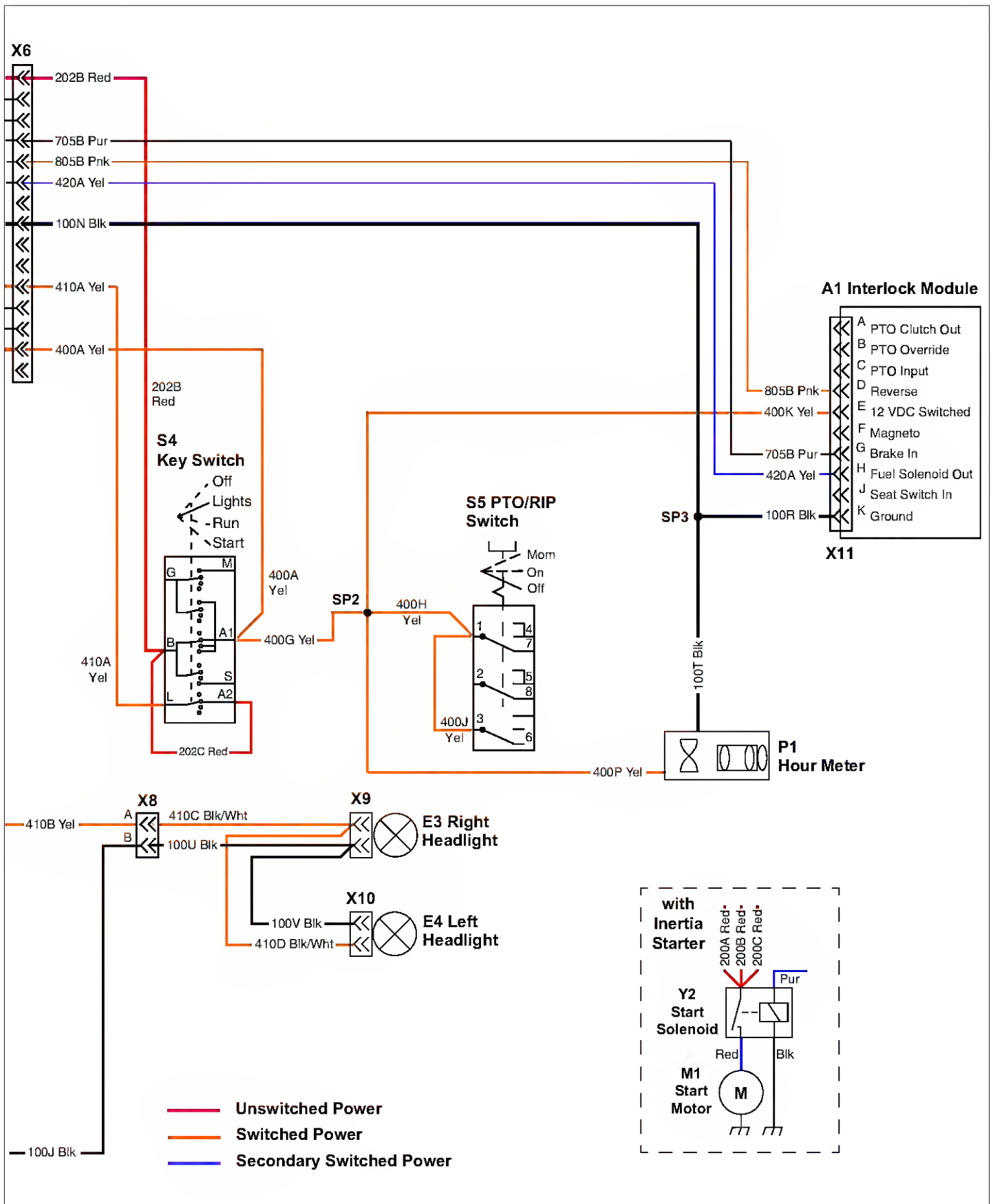
This circuit is controlled by the A1 interlock module.

# ELECTRICAL THEORY OF OPERATION (SN 040001-)

## Power Circuit Wiring Schematic (Shown with Lights On)



# ELECTRICAL THEORY OF OPERATION (SN 040001-)



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# ELECTRICAL THEORY OF OPERATION (SN 040001-)

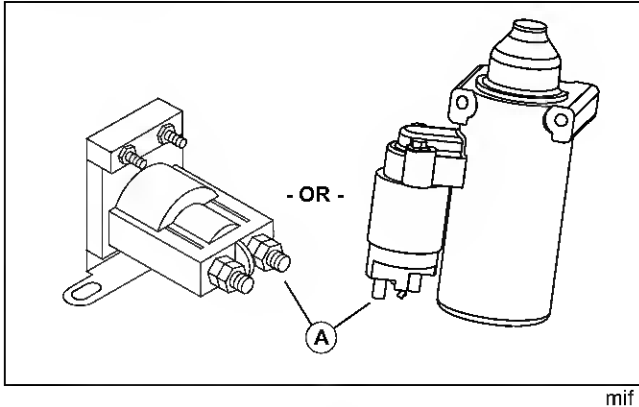
## Power Circuit Diagnostics

### Test Procedure A:

#### Test Conditions:

- Battery properly connected.
- Key switch off.

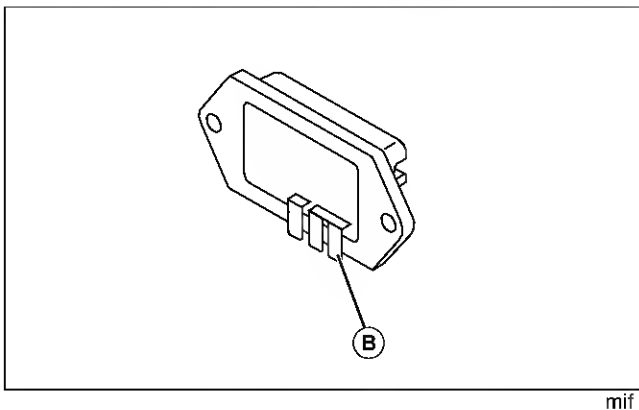
#### Unswitched Power:



1. Is battery voltage present at the starting motor solenoid 200A Red wire (A)?

Yes: Go to next step.

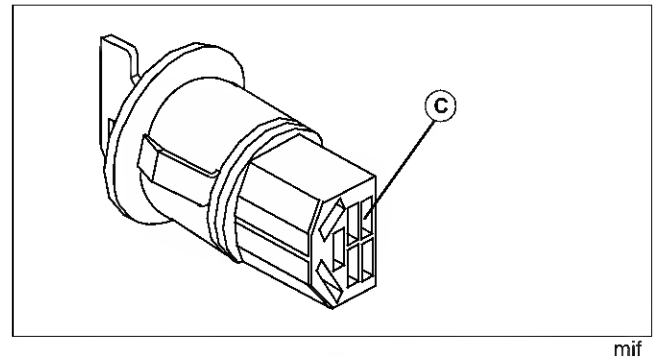
No: Check the battery connections. If ok, test the battery. See "Battery Test" on page 343.



2. Is battery voltage present at the N1 voltage regulator/rectifier 200B Red wire (B)?

Yes: Go to next step.

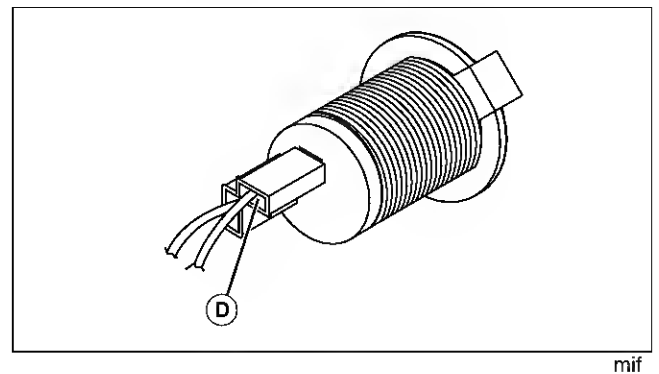
No: Test the 200B Red fuse link.



3. Is battery voltage present at the S4 key switch, 202B Red wire (terminal "B") (C)?

Yes: Go to next step.

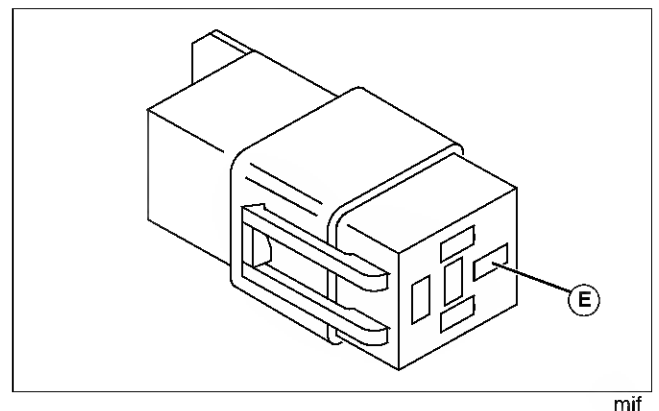
No: Check 200C Red fuse link, X2 connector 201 Red wire, F1 fuse, 202A Red wire, X6 connector, and 202B Red wire and connections.



4. Is battery voltage present at the (optional) power port (D)?

Yes: Go to next step.

No: Check F2 fuse. Check the 203 Red wire and connections.



5. Is battery voltage present at K1 start relay, 204 Red wire (terminal 30) (E)?

Yes: Go to next procedure.

No: Check F3 fuse, 204 Red wire and connections.

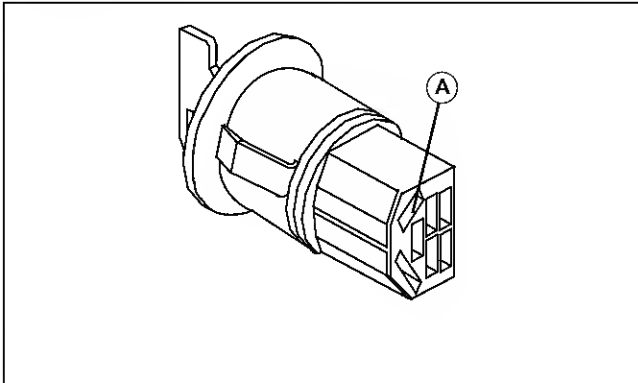
# ELECTRICAL THEORY OF OPERATION (SN 040001-)

## Test Procedure B:

### Test Conditions:

- Key switch to On position.
- Transmission in neutral (reverse switch closed).
- All other switches off.

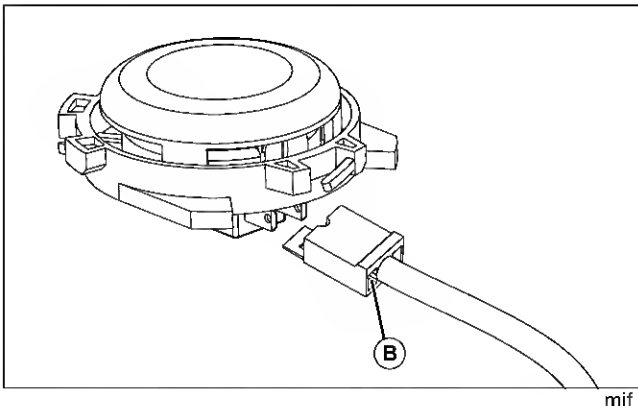
### Switched Power:



1. Is battery voltage present at the S4 key switch, 400A Yel wire (terminal A1) (A)?

Yes: Go to next step.

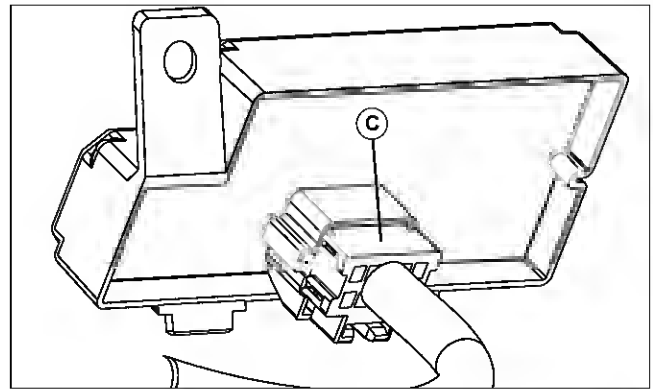
No: Test key switch. See "Key Switch Test (SN 040001-)" on page 359.



2. Is battery voltage present at the S3 seat switch, 400E Yel wire (B)?

Yes: Go to next step.

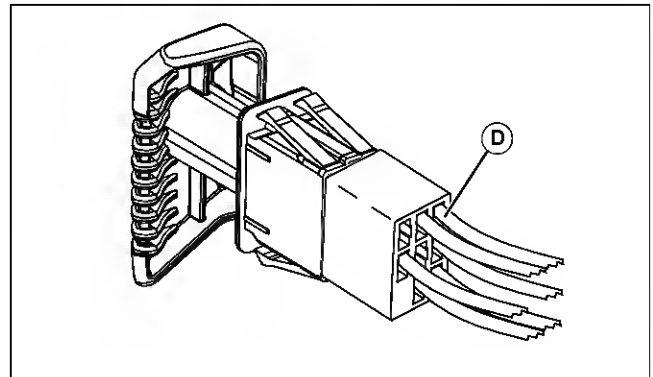
No: Check 400A Yel wire, X6 connector, 400B Yel wire (at S1 brake switch), 400D Yel wire (at S2 reverse switch), 400E Yel wire and connections.



3. Is battery voltage present at the interlock module connector X11, 805B Pnk wire (C)?

Yes: Go to next step.

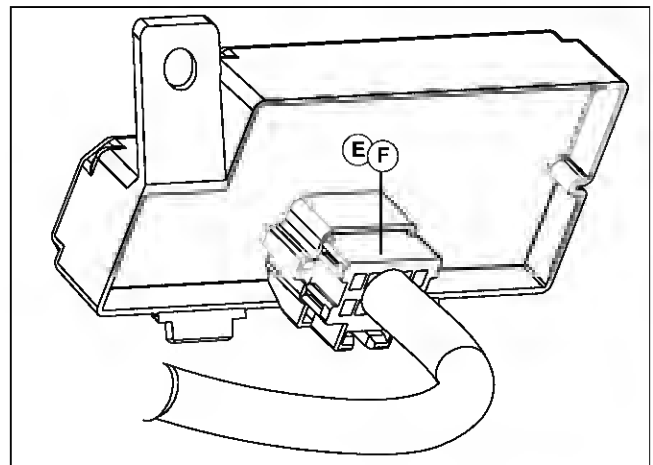
No: Check 805B Pnk wire, X6 connector, 805A Pnk wire. If OK, test S2 reverse switch. See "Reverse Switch Test and Adjustment" on page 357.



4. Is battery voltage present at the PTO/RIP switch, 400H Yel wire (terminal 1) (D)?

Yes: Go to next step.

No: Check 400H and -G Yel wires and connections.



## ELECTRICAL THEORY OF OPERATION (SN 040001-)

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5. Is battery voltage present at the interlock module 400K Yel wire (E)?

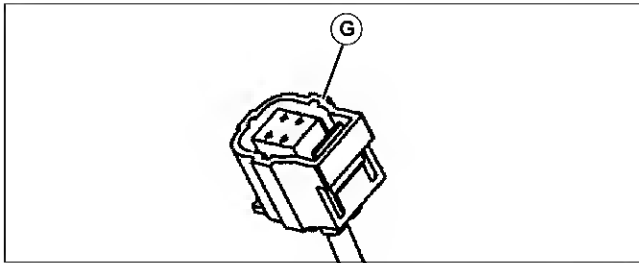
Yes: Go to next step.

No: Check 400G and 400K Yel wires and connections.

6. Is there continuity between interlock module 100R Blk wire (F) and ground?

Yes: Test complete.

No: Check 100R Blk wire, X6 connector, 100E and 100C Blk wires, X5 connector, and 100B Blk wire.



MX37977

7. Is battery voltage present at P1 hour meter, 400P Yel wire (G)?

Yes: Ensure that there is continuity to ground over 100T Blk wire. If OK, power circuit checks complete. See specific circuit diagnosis if problems persist.

No: Check 400G and -P Yel wires and connections.



## Cranking Circuit Operation

### Function:

To energize the starting motor solenoid and engage the starting motor to crank the engine.

### Operating Conditions:

- Key switch in Start position.
- Brake locked, switch closed.
- PTO/RIP switch in Off position.

### Theory of Operation:

The starting motor may be either of the solenoid shift (with integrated solenoid) or inertia style (separate solenoid).

The unswitched power circuit provides current to the S4 key switch. Fuse F3 protects the cranking circuit. Power flows from the battery positive (+) terminal to the starter solenoid battery terminal, 200C fuse link, 201 Red wire, F1 fuse, 202A and -B Red wires, to the key switch.

Moving the key switch from the Off position energizes the switched power circuit and A1 interlock module. The module is used to control the fuel shutoff solenoid and magneto primary circuit.

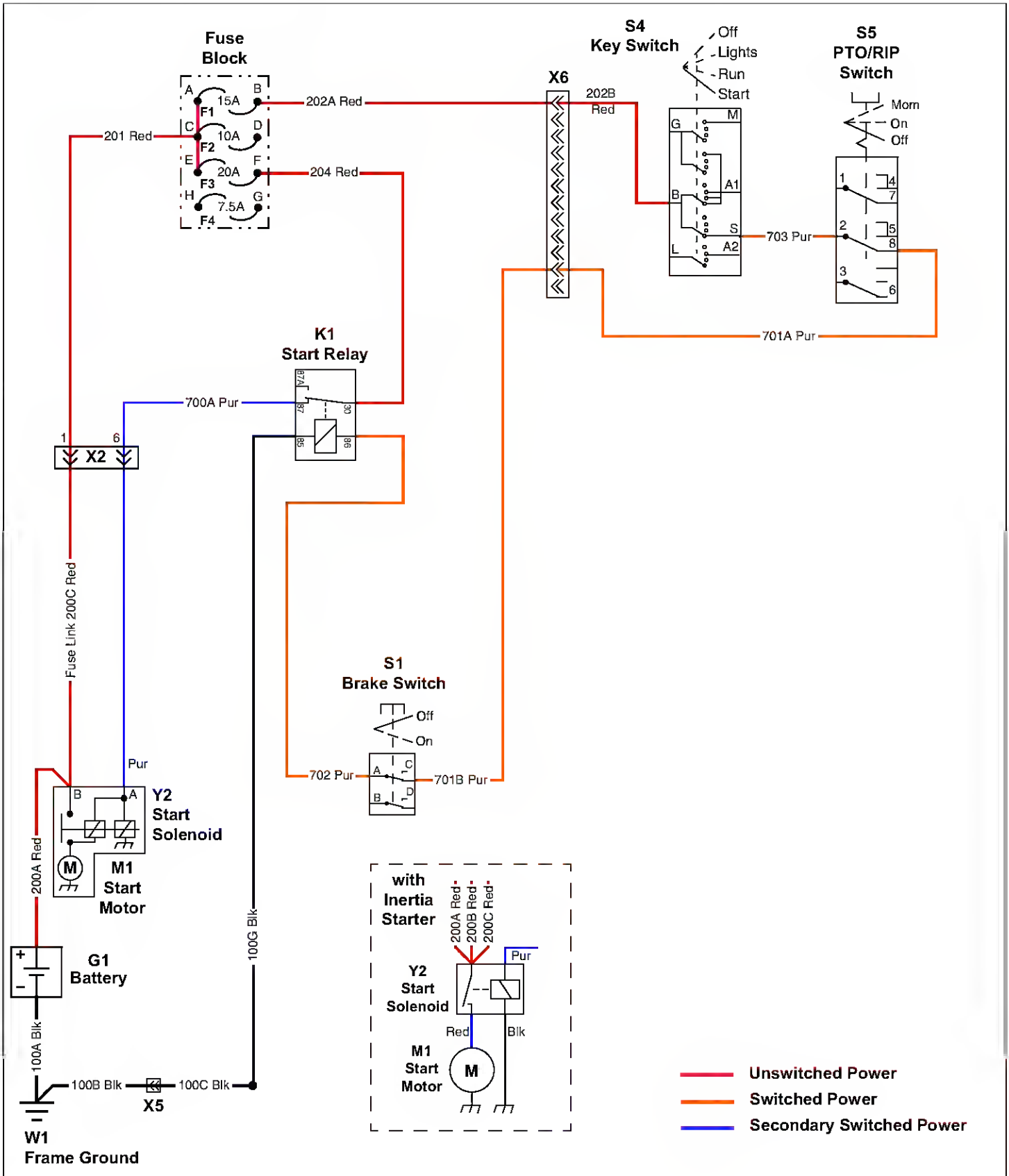
When the S4 key switch is turned to the Start position, the switch "S" terminal powers the 703 Pur wire. With the S5 PTO/RIP switch in the Off position, the 701A Pur wire is then energized. Connector X6 mates wire 701A to wire 701B and the S1 brake switch "C" terminal. With the switch in the closed position (brake on), power is supplied to the K1 start relay over the 702 Pur wire. This will energize the relay coil, which is grounded by the 100G wire. The relay contacts close, allowing power to the Y2 start solenoid via the 700A Pur wire and Pur wire of engine wiring harness.

The energized Y2 start solenoid pulls in a plunger. On a solenoid shift motor, the plunger also pushes the starter motor pinion gear forward, engaging the flywheel. The plunger closes the solenoid main contacts. High current from the battery flows through the contacts to the M1 starting motor. An inertia-type motor will engage the flywheel once the starting motor begins to spin.

With the starting motor cranking the engine, the A1 interlock module must receive an input from the brake switch in order to activate the fuel shutoff solenoid (See "Fuel Shutoff Solenoid Circuit Operation" on page 291), as well as open the shunt ground path to the magnetos (See "Ignition Circuit Operation" on page 287). This input circuit uses switched power from the 400B Yel wire, across the brake switch (brake locked), to the 705A and 705B Pur wires and the A1 interlock module.

# ELECTRICAL THEORY OF OPERATION (SN 040001-)

## Cranking Circuit Wiring Schematic



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# ELECTRICAL THEORY OF OPERATION (SN 040001-)

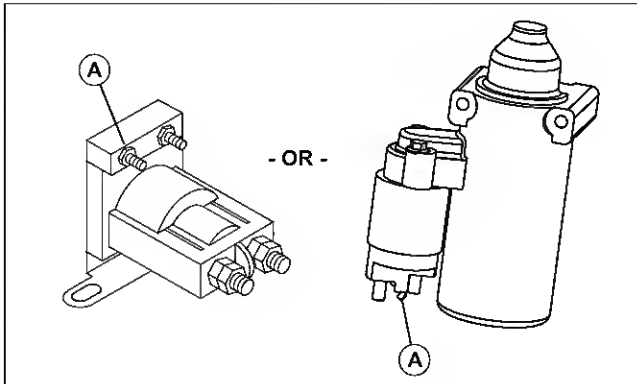
## Cranking Circuit Diagnostics

### Test Procedure A:

#### Test Conditions:

- Park machine safely.
- Key switch in START position.
- PTO/RIP switch OFF.
- Park brake ON.

### Cranking Power

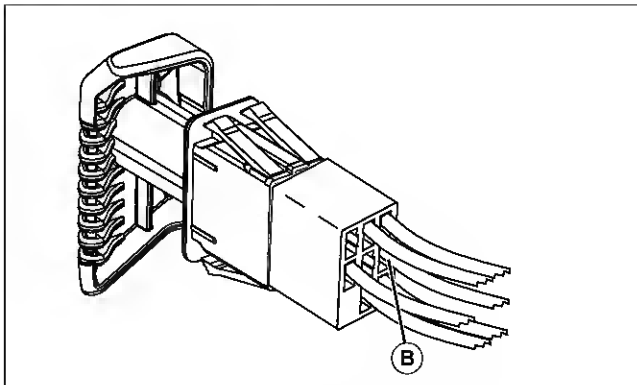


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1. Is battery voltage present at the starting motor solenoid, Pur wire (A)?

Yes: Cranking circuit is operational. Test the starting solenoid and the starting motor. See "Starting Solenoid Test" on page 349.

No: Go to next step.



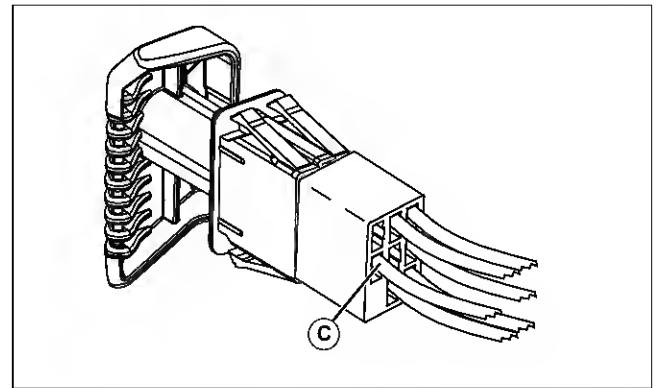
mif

2. Is battery voltage present at the PTO/RIP switch, 703 Pur wire (terminal 2) (B)?

Yes: Go to next step.

No: Check 703 Pur wire and connections.

No: Test S4 key switch. See "Key Switch Test (SN 040001-)" on page 359.

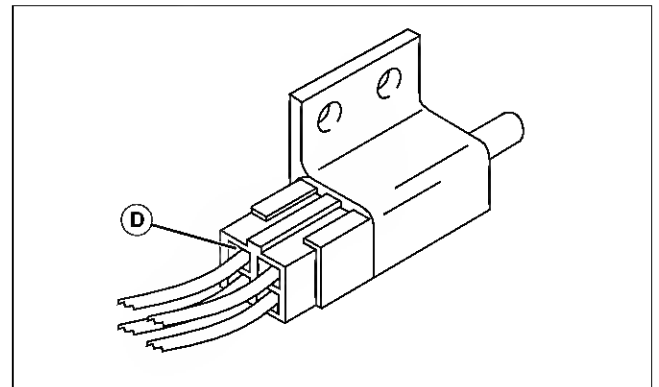


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3. Is battery voltage present at the PTO/RIP switch, 701A Pur wire (terminal 8) (C)?

Yes: Go to next step.

No: Test PTO/RIP switch. See "PTO/RIP Switch Test" on page 353.

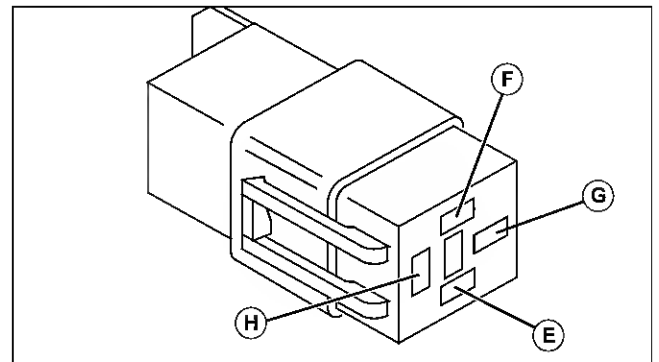


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4. Is battery voltage present at the brake switch, 701B Pur wire (D)?

Yes: Go to next step.

No: Check 701B Pur wire, X6 connector, and 701A Pur wire.



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5. Is battery voltage present at K1 start relay, 702 Pur wire (terminal 86) (E)?

Yes: Go to next step.

## ELECTRICAL THEORY OF OPERATION (SN 040001-)

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No: Check 702 Pur wire and connections.

No: Test S1 brake switch. See "Brake Switch Test" on page 356.

6. Is there continuity between K1 start relay 100G Blk wire (terminal 85) (F) and ground?

Yes: Go to next step.

No: Check 100G, -C and -B Blk wires to W1 ground. Check connector X5.

7. Is battery voltage present at K1 start relay, 204 Red wire (terminal 30) (G)?

Yes: Go to next step.

No: Check F3 fuse and 204 Red wire.

8. Is battery voltage present at K1 start relay, 700A Pur wire (terminal 87) (H)?

Yes: Check the solenoid Pur wire, connector X2 and the 700A Pur wire.

No: Test start relay. See "Relay Test (SN 040001-)" on page 352.

# ELECTRICAL THEORY OF OPERATION (SN 040001-)

## Charging Circuit Operation

### Function:

To maintain battery voltage at 12.4 volts or higher.

### Operating Conditions:

The engine must be running for the charging system to operate.

- Key switch On, engine running
- Operator on seat

or,

- Key switch On, engine running
- Brake locked
- Operator off seat

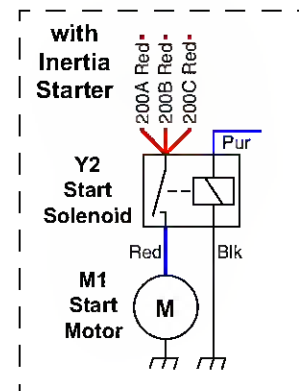
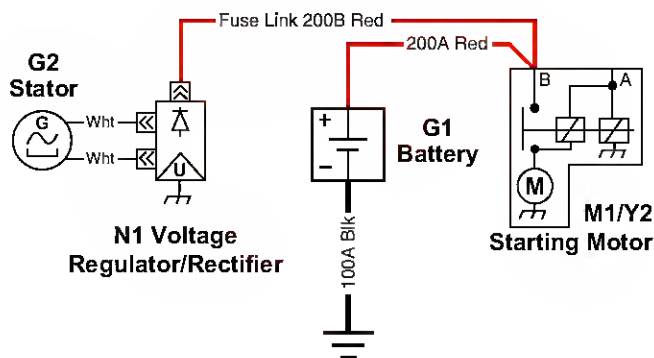
### Theory of Operation:

The charging system is a permanent magnet and stator design.

A permanent magnet is located in the flywheel. As the flywheel turns, the magnet moves across the G2 stator, inducing an AC current in the stator windings. The AC current is converted by the N1 regulator/rectifier into the DC current needed to charge the battery. The regulator adjusts the charging current in order to maintain the system voltage at approximately 14.7 volts.

Fuse link 200B protects the charging system from excessive currents. The regulator/rectifier is connected to frame ground via a black jumper wire.

## Charging Circuit Wiring Schematic



# ELECTRICAL THEORY OF OPERATION (SN 040001-)

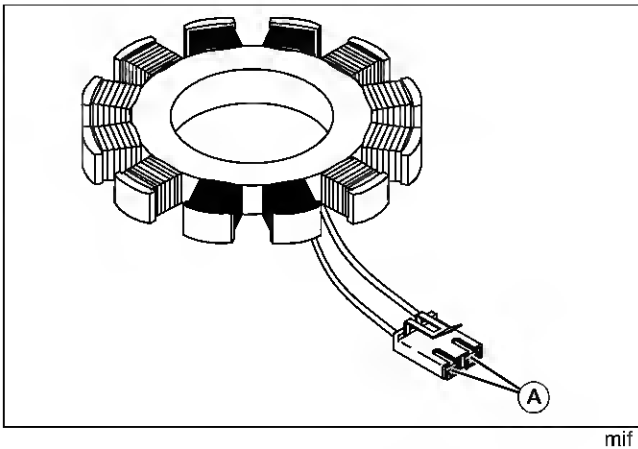
## Charging Circuit Diagnostics

### Test Procedure A:

#### Test Conditions:

- Machine parked safely.
- Park brake locked.
- PTO in off position.
- Battery fully charged.
- Stator connector unplugged.
- Voltmeter set to AC.
- Engine running at full throttle.

### Charging System - Stator



1. Is the voltage measured between stator lead(s) approximately 28 volts AC or higher (A)?

Yes: Go to next procedure.

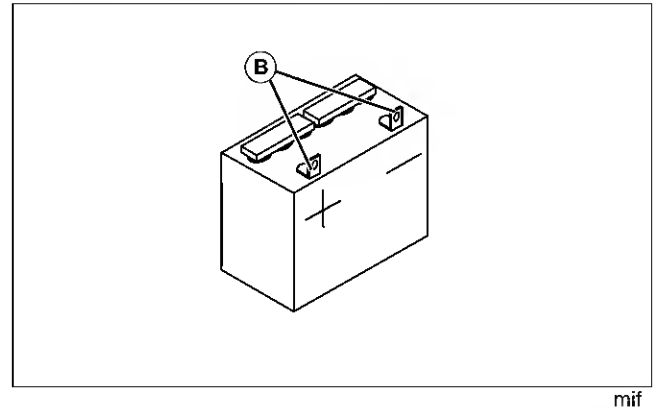
No: If below 28 volts AC, replace stator.

### Test Procedure B

#### Test Conditions:

- Machine parked safely.
- Park brake locked.
- PTO in off position.
- Battery fully charged.
- Stator connected.
- All electrical loads off (headlights, accessories).
- Engine running at low idle, then high idle during test.

### Charging System



1. Does the voltage across the battery terminals rise from approximately 12.5 VDC to 13.5 VDC or higher when the throttle is moved from low idle to high idle?

Yes: Test complete.

No: Check for poor connections between battery, starting motor solenoid and voltage regulator/rectifier. Check regulator grounding wire.

No: Test voltage regulator/rectifier. See "Regulated Voltage Test" on page 345 and other related tests.

## Ignition Circuit Operation

### Function:

To control the ignition coils ability to create a spark.

### Operating Conditions, Stopping Engine:

- Key switch in Off position

- or -

- Operator off seat
- Park braked unlocked.

### Theory of Operation, Stopping Engine:

The engine is shut off by grounding the T1 and T2 ignition coils. With the ignition primary coils grounded, a spark cannot be produced.

Operating current for the interlock module is supplied by the switched power circuit. When the key switch is in the Off position, a module-created ground path shunts the 900-series Wht wires of the ignition coils and P1 hour meter.

If the interlock module senses that the logic inputs from both the seat switch (810B Pnk wire) and brake switch (705B Brn wire) are removed, the 900-series Wht wires are again grounded.

The seat switch and brake switch also provide inputs to the interlock module for the fuel shutoff solenoid circuit. If both the seat switch and brake switch are in the off position, the fuel shutoff solenoid is de-energized, stopping the flow of fuel within the carburetor.

### Operating Conditions, Running Engine:

- Key switch in On or Start position
- Operator on seat
- or -
- Key switch in On or Start position
- Operator off seat
- Park braked locked.

### Theory of Operation, Running Engine:

The ignition system is a transistor-controlled magneto design. Ignition timing is controlled by the transistor and is not adjustable. As the engine turns, the flywheel magnet induces a current pulse into the magneto ignition coil. The ignition coil steps up the pulse to produce a high voltage arc across the spark plug gap. This spark ignites the fuel/air mixture in the engine cylinder.

Operating current for the interlock module is supplied by the switched power circuit. With the key switch in the On position and the seat and/or brake switch activated, the module will open the ground shunt to the ignition primary coils. A high-voltage spark can now be generated.

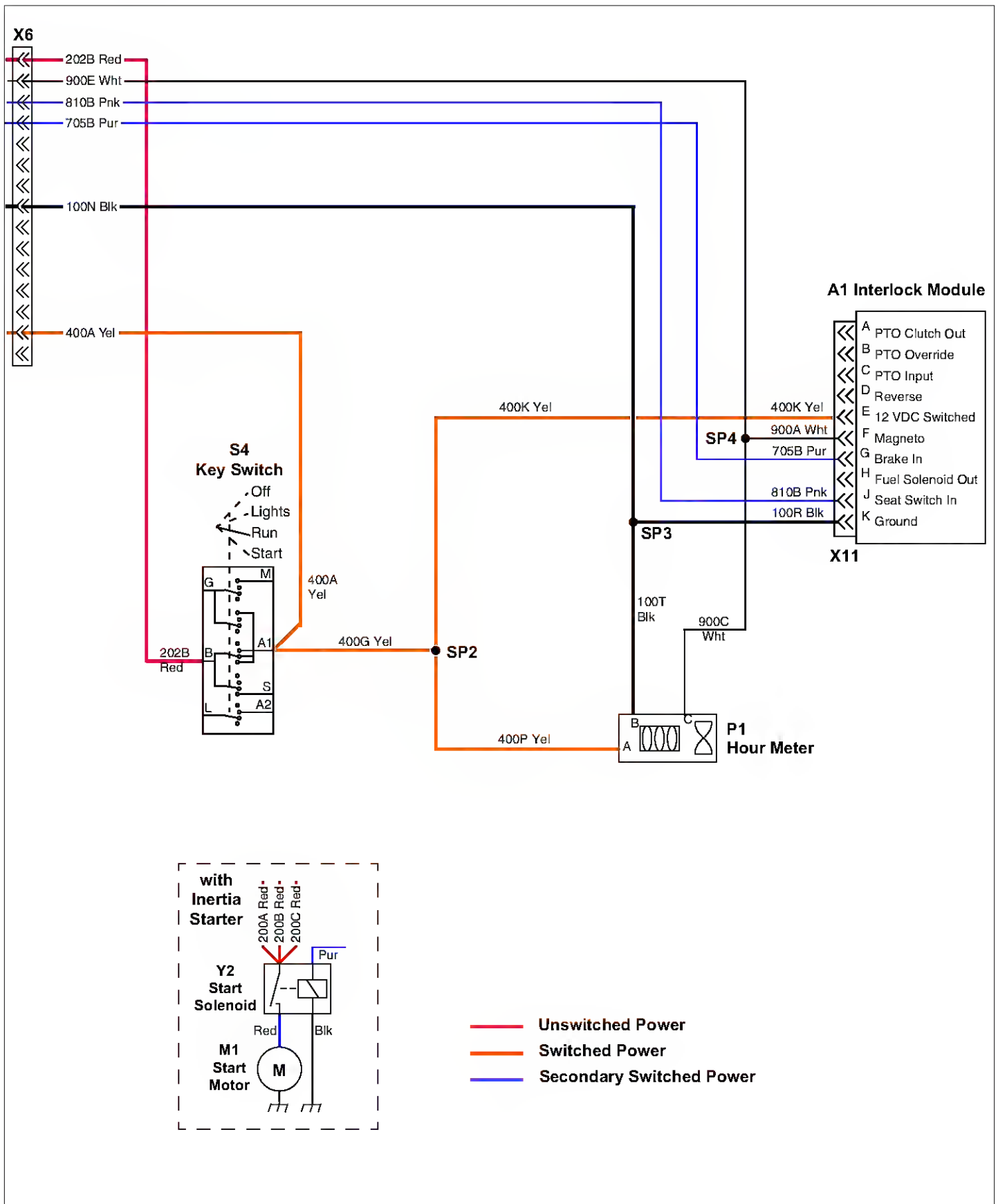
Additionally, the interlock module energizes the fuel shutoff solenoid, allowing fuel to flow within the carburetor. See "Fuel Shutoff Solenoid Circuit Operation" on page 291.

The interlock module is a solid-state device with no field-serviceable components.





# ELECTRICAL THEORY OF OPERATION (SN 040001-)



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# ELECTRICAL THEORY OF OPERATION (SN 040001-)

## Ignition Circuit Diagnostics

### Test Procedure A:



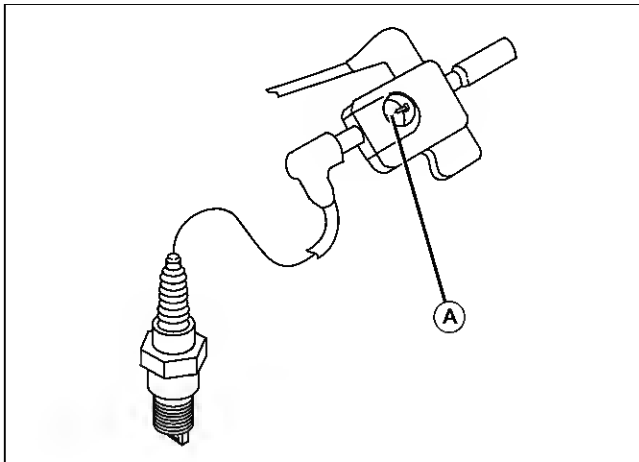
**Caution: Avoid Injury! Stay clear of moving parts. Engine will turn over and may start during this test.**

#### Test Conditions:

- Power circuits checked and OK. See "Power Circuit Diagnostics" on page 278.
- Machine parked safely with park brake locked.
- Ignition spark tester installed between spark plug and spark plug lead.
- PTO off.
- Fuel shutoff solenoid disconnected to prevent starting.
- Key switch in Start position, engine cranking during test.

**Note: Before replacing ignition components, first verify that the flywheel key is not sheared or distorted.**

#### Spark Test:



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1. Does the spark tester (A) indicate a hot, blue spark?

Yes: Check spark plug gap and condition of spark plug. If plug is good, continue testing ground circuit.

No: Test ignition coil and ignition module. Check armature air gap. See ignition coil adjustment in respective engine section. Test flywheel magnets. See "Flywheel Ignition Magnet Test" on page 348. If ok, go to next procedure.

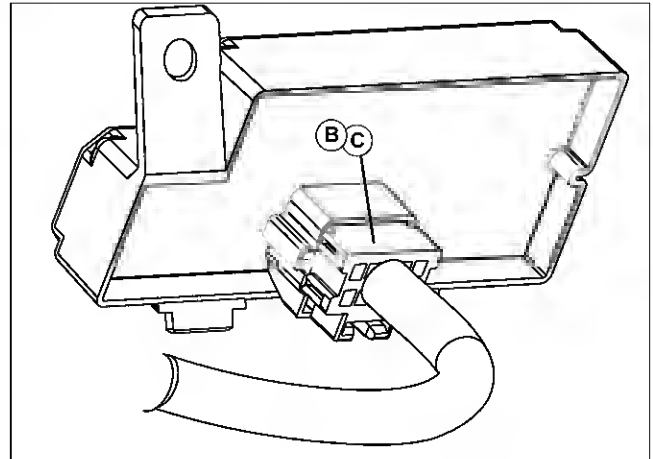
Repeat procedure for opposite spark plug.

### Test Procedure B:

#### Test Conditions:

- Machine parked safely with park brake locked.
- Key switch in Off position.

#### Ignition Off:



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1. Unplug connector X11 from interlock module. Set meter to diode test. At the connector, measure between the 900A Wht wire (B) and ground. Reverse test leads and repeat measurement. Does meter read approximately .6 ~ .7 volts (one diode drop) in one direction?

Yes: Go to next step.

No: Check the 900-series Wht wires and connections.

2. Is there continuity between the interlock module connector X11, 100R Blk wire (C) and ground?

Yes: Ensure that safety interlock (seat and brake switch) circuits are functioning properly.

Yes: Replace the A1 interlock module.

No: Check the 100R, -N, -E, -C and -B Blk wires and connections.

## Fuel Shutoff Solenoid Circuit Operation

### Function:

To energized the fuel shutoff solenoid when the proper operating condition are met.

### Operating Conditions:

- Key switch in START or ON position
- Operator ON the seat
- or -
- Brake pedal depressed

### Theory of Operation:

The Y1 fuel shutoff solenoid uses an electromagnet to operate a plunger. The plunger stops fuel flow in the carburetor when the solenoid is de-energized. The interlock module provides power to the fuel shutoff solenoid. When the interlock module is de-energized, the fuel shutoff solenoid stops fuel flow just before the spark is removed, helping to prevent backfire at engine shutdown.

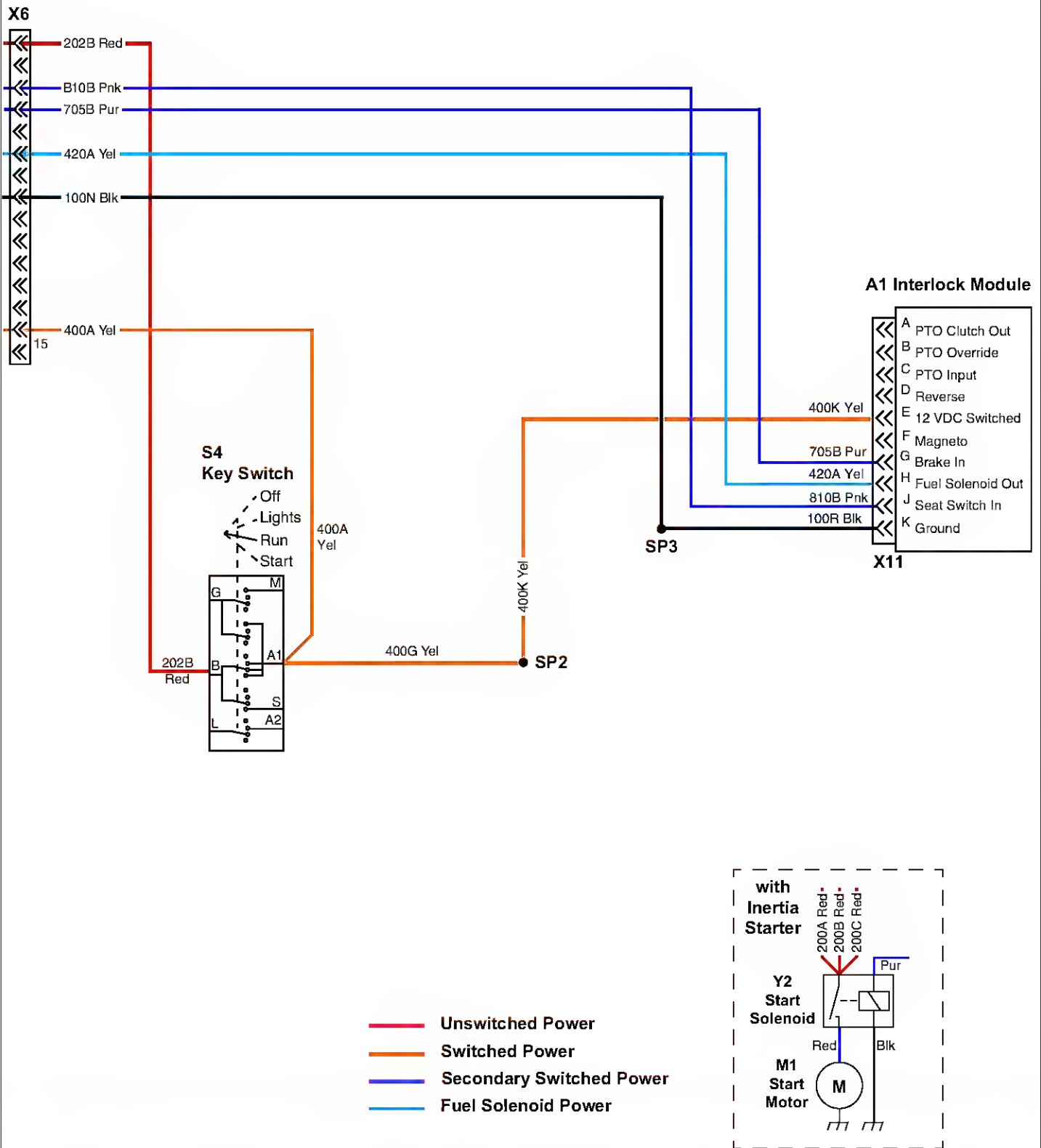
To activate the fuel shutoff solenoid, the interlock module requires an input signal from a closed brake or seat switch. If neither signal is present, fuel is cut off and ignition shorted, stopping the engine.

From the S4 key switch, the 400G and -K Yel wires power the interlock module. At the same time, power for the brake and seat switches is carried by the 400A, -B, -D and -E Yel wires.

The 810A and -B Pnk wires connect the interlock module to the seat switch, while the 705A and -B Pur wires connect the module to the brake switch. These wires provide the input signals for the interlock module. The interlock module sources output current to the fuel shutoff solenoid via the 420A and -B Yel wires, and engine harness Grn wire. When energized, the fuel shutoff solenoid pulls in the plunger, allowing fuel to flow through the carburetor.



# ELECTRICAL THEORY OF OPERATION (SN 040001-)



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# ELECTRICAL THEORY OF OPERATION (SN 040001-)

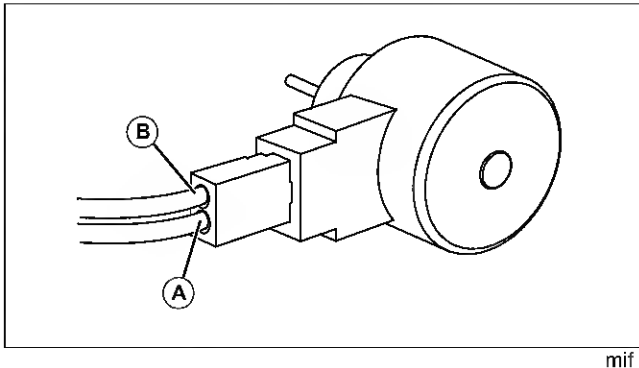
## Fuel Shutoff Solenoid Circuit Diagnostics

### Test Procedure A:

#### Test Conditions:

- Brake locked.
- PTO OFF.
- Key switch on, engine not running.
- Operator off seat.
- Transmission in neutral.

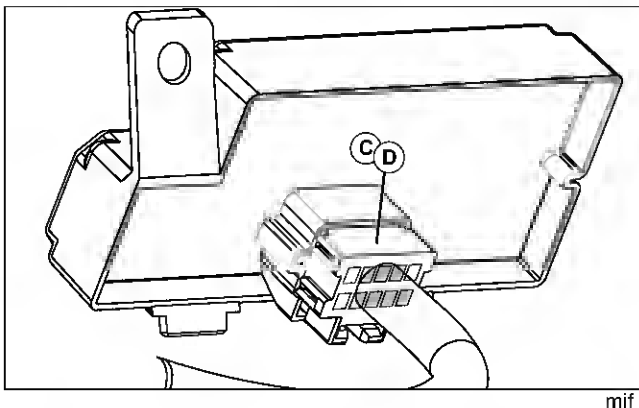
### Fuel Shutoff Solenoid - Brake Circuit:



1. Is battery voltage present at the fuel shutoff solenoid Grn wire (A)?

Yes: Fuel shutoff circuit is functioning properly. Test the fuel shutoff solenoid. See "Fuel Shutoff Solenoid Test" on page 352. Check Blk wire (B) connection to ground.

No: Go to next step.

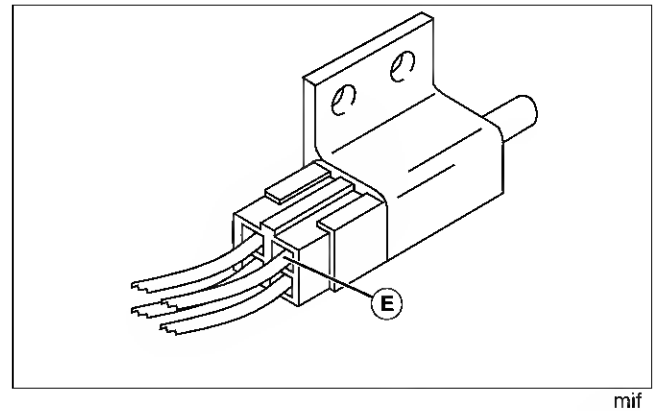


2. Is battery voltage present at interlock module connector wires 400K Yel (C) and 705B Pur (D)?

Yes: Check the 420B and -A Yel wires and Grn wire and connections. If ok, replace the interlock module.

No: 400K Yel - See "Switched Power:" on page 279.

No: 705B Pur - go to next step.



3. Is battery voltage present at the brake switch, 705A Pur wire (E)?

Yes: Check the 705B and -A Brn wires and connections. If ok, replace the A1 interlock module.

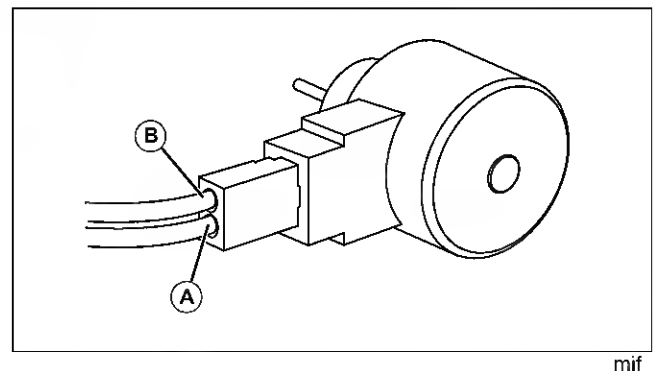
No: Recheck switched power circuit. See "Switched Power:" on page 279. Test Brake switch. See "Brake Switch Test" on page 356.

### Test Procedure B:

#### Test Conditions:

- PTO OFF.
- Key switch on, engine not running.
- Operator on seat.
- Transmission in neutral.
- Machine on level surface, Brake off.

### Fuel Shutoff Solenoid - Seat Circuit:

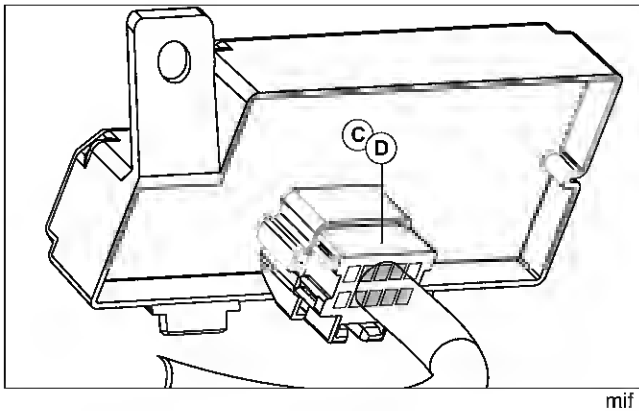


1. Is battery voltage present at the fuel shutoff solenoid Grn wire (A)?

Yes: Fuel shutoff circuit is functioning properly. Test the fuel shutoff solenoid. See "Fuel Shutoff Solenoid Test" on page 352. Check Blk wire (B) connection to ground.

No: Go to next step.

# ELECTRICAL THEORY OF OPERATION (SN 040001-)

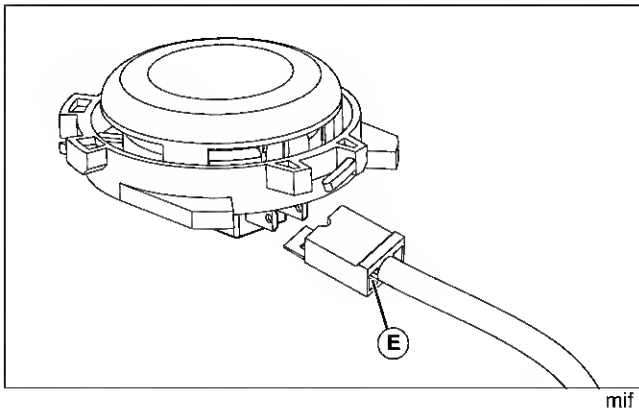


2. Is battery voltage present at interlock module connector wires 400K Yel (C) and 810B Pnk (D)?

Yes: Check the 420B and -A Yel wires and Grn wire and connections. If ok, replace the interlock module.

No: 400K Yel - See "Switched Power:" on page 279.

No: 810B Pnk - go to next step.



3. Is battery voltage present at the seat switch, 810A Pnk wire (E), with switch depressed?

Yes: Check the 810A and -B Pnk wires and connections. If OK, replace the interlock module.

No: Recheck switched power circuit. See "Switched Power:" on page 279. Test S3 seat switch. See "Seat Switch Test (SN 040001-)" on page 358.

## PTO/RIP Circuit Operation

### PTO Clutch Operating Conditions:

- Key switch On
- Operator on seat
- PTO/RIP switch On
- Brake released
- Transmission in forward or neutral

or;

- Key switch ON
- Operator on seat
- Brake released
- PTO/RIP switch in Momentary ON position while transmission shifted to reverse, then PTO/RIP switch in On position while transmission in reverse.

### Theory of Operation:

The PTO is electro/mechanical device (electric clutch) powered and controlled by the A1 interlock module.

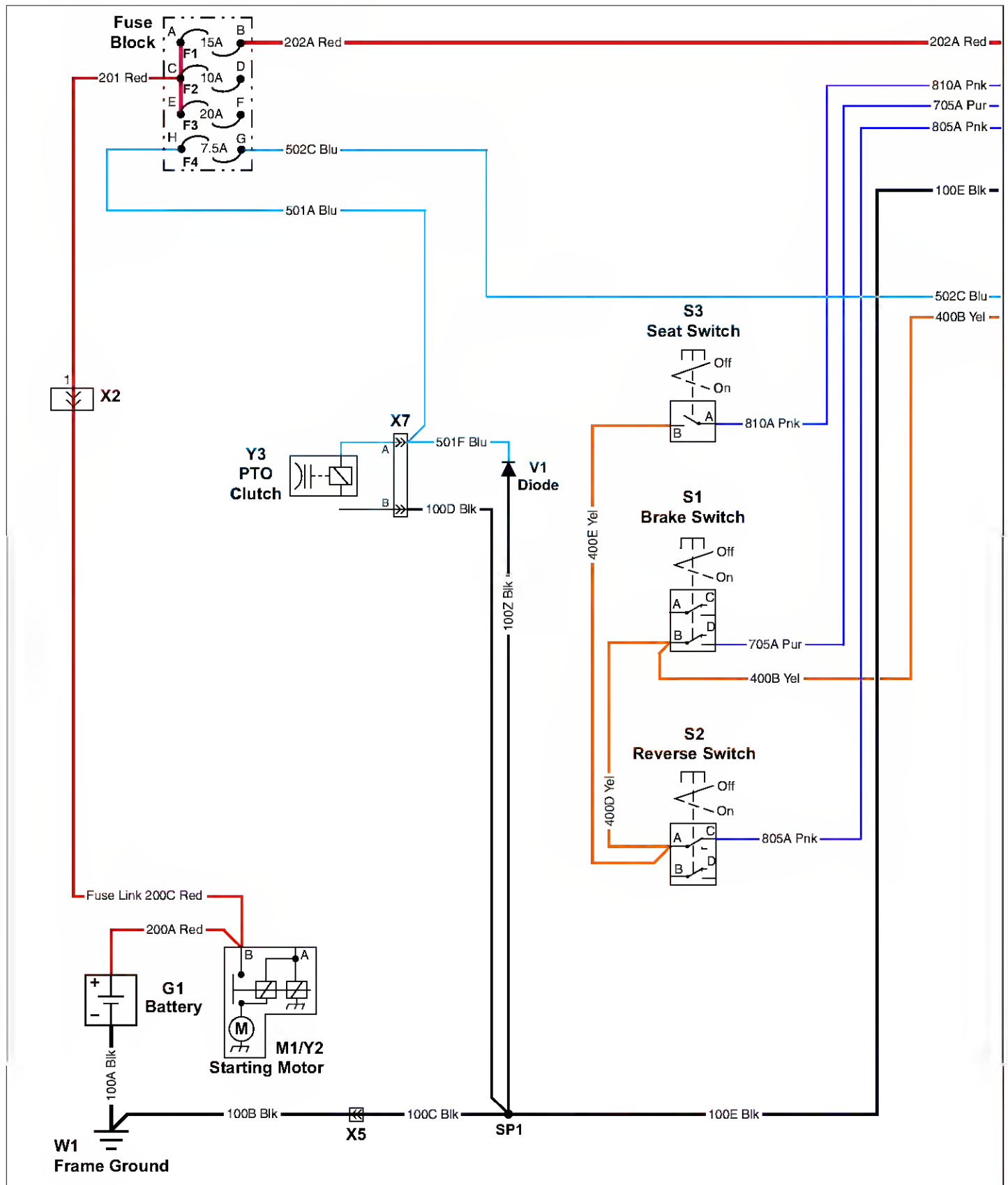
The engine crankshaft drives the PTO clutch. When operating conditions are met, the interlock module output (Pin A) sources 12 VDC to energize the PTO electric clutch. The clutch sheave is then engaged with the engine crankshaft. The interlock module will disengage the PTO clutch should any operating condition not be met.

### The interlock module performs the following functions:

- Turn on the electric clutch if the operator is in the seat, the PTO/RIP switch is in the ON position, and the transmission is in forward or neutral.
- Maintain power to the electric clutch if the operator is in the seat, and chooses to mow in reverse. By lifting the PTO/RIP switch to the Momentary ON position while shifting into reverse, the reverse override function is enabled, latching the power to the clutch.
  - Disables the reverse override when the operator shifts the transmission from reverse to forward or neutral.
- Turn off and latch off the electric clutch if the PTO is on and the operator shifts into reverse without lifting the PTO/RIP switch. To reset the latch, the operator must place the PTO/RIP switch in the OFF position.
- Turn off and latch off the electric clutch if the operator gets off the seat. A short time delay protects against bouncing. To reset the latch, the operator must place the PTO/RIP switch in the OFF position.
- Turn off and latch off the electric clutch if the operator enables the brake switch.

# ELECTRICAL THEORY OF OPERATION (SN 040001-)

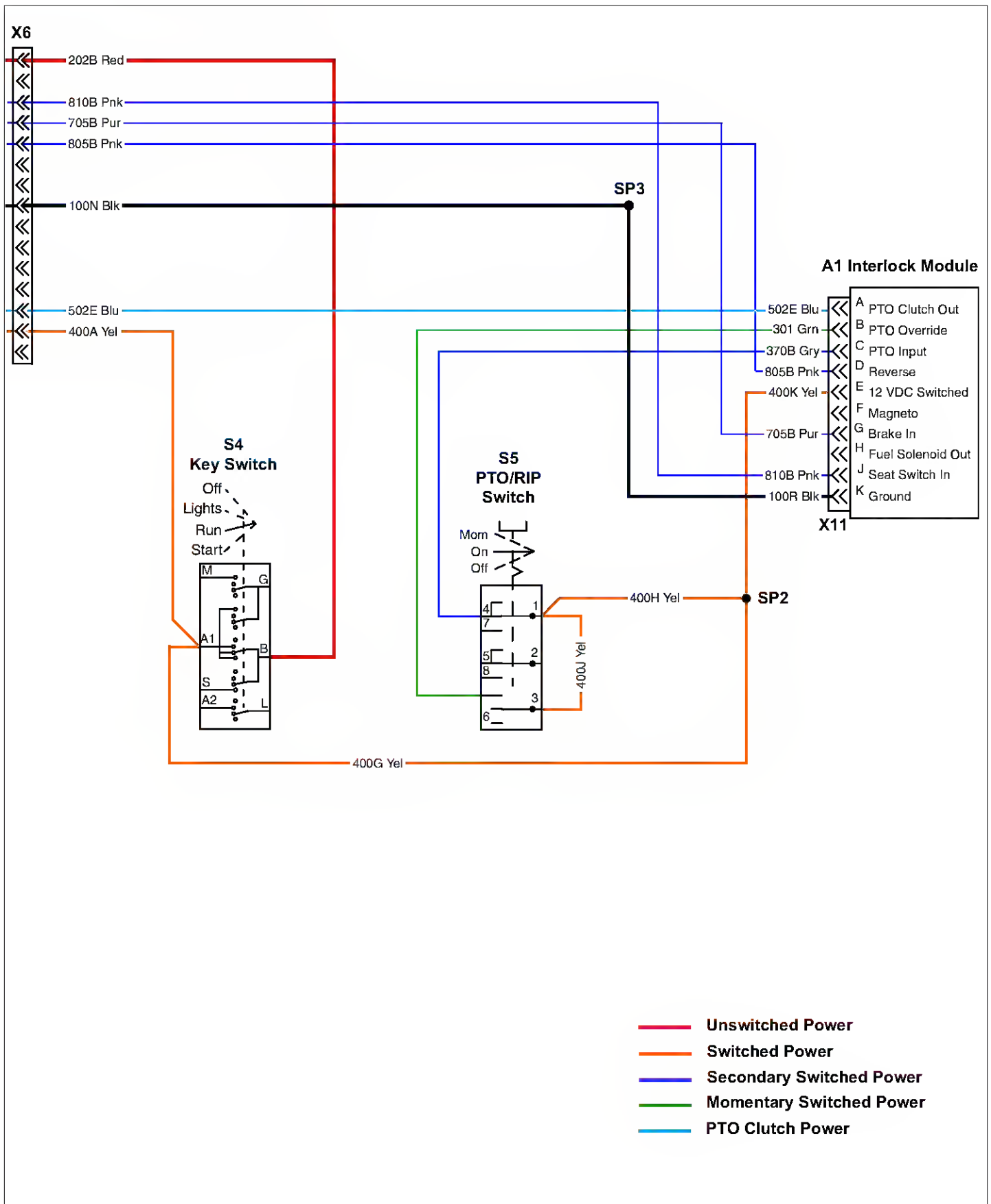
## PTO/RIP Circuit Wiring Schematic



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# ELECTRICAL THEORY OF OPERATION (SN 040001-)



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# ELECTRICAL THEORY OF OPERATION (SN 040001-)

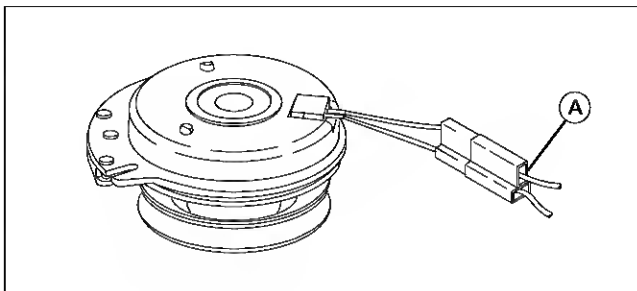
## PTO/RIP Circuit Diagnostics

### Test Procedure A:

#### Test Conditions:

- Power circuits checked and OK. See "Power Circuit Diagnostics" on page 278.
- Brake unlocked.
- Transmission in neutral.
- Operator on seat.
- Key switch On, engine not running.
- PTO/RIP switch On, reset as required.

#### PTO On:



1. Is battery voltage present at the PTO clutch connector X7, 501A Blu wire (A)?

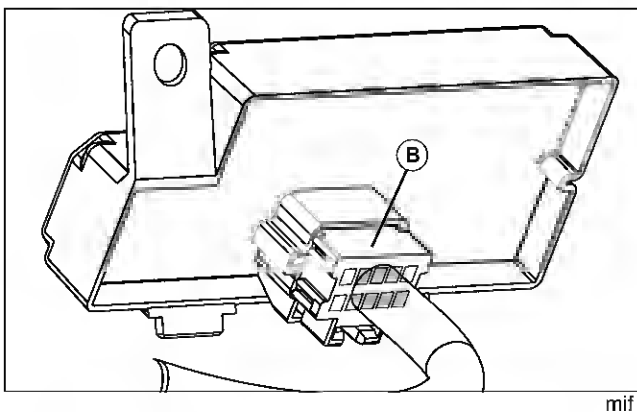
Yes: PTO clutch circuit is functional. Test the PTO clutch. See "PTO Clutch Test" on page 353.

Yes: Check for continuity to ground on 100D Blk wire.

No: Ensure that safety interlock (seat, brake and reverse switch) circuits are functioning properly.

No: Test F4 fuse. Check 501A, 502C and -E Blu wires.

No: Test V1 Diode. See "Diode Test" on page 355.

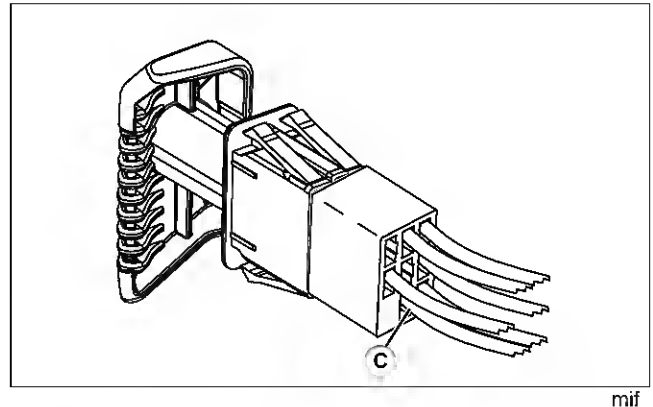


2. Is battery voltage present at the interlock module connector 370B Gry wire (B)?

Yes: Recheck all power, ground and safety interlock

circuits. If OK, replace A1 interlock module.

No: Check the 370B Gry wire and connections. Test PTO/RIP switch. See "PTO/RIP Switch Test" on page 353.



3. When PTO switch is pulled up to the RIP position, does battery voltage appear at the 301 Grn wire (C)? Return PTO switch to ON position.

Yes: Check the 301 Grn wire and connections. Go to next procedure.

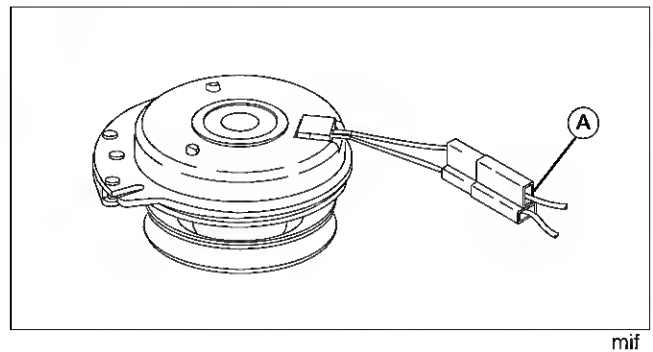
No: Test PTO/RIP switch. See "PTO/RIP Switch Test" on page 353.

### Test Procedure B:

#### Test Conditions:

- Brake unlocked.
- Reverse pedal depressed (transmission moved to reverse) for each test.
- Operator on seat.
- Key switch On, engine not running.
- PTO/RIP switch On, reset as required.

#### Reverse Shutoff Circuit:

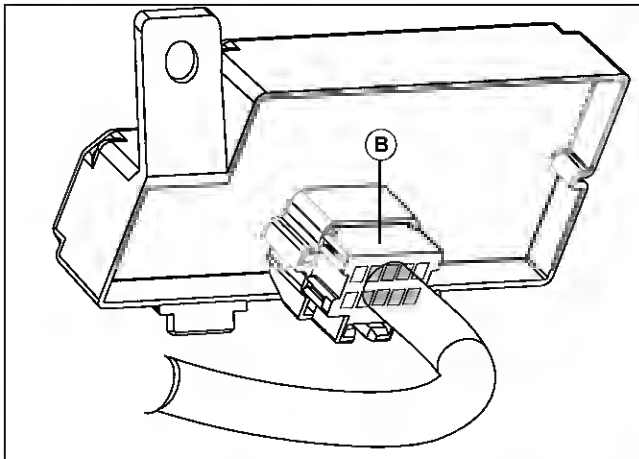


1. Does voltage at the PTO clutch connector X7, 501A Blu wire (A) drop to less than 0.5 volts when the reverse pedal is depressed?

# ELECTRICAL THEORY OF OPERATION (SN 040001-)

Yes: PTO clutch reverse shutoff circuit is functional.

No: Go to next step.

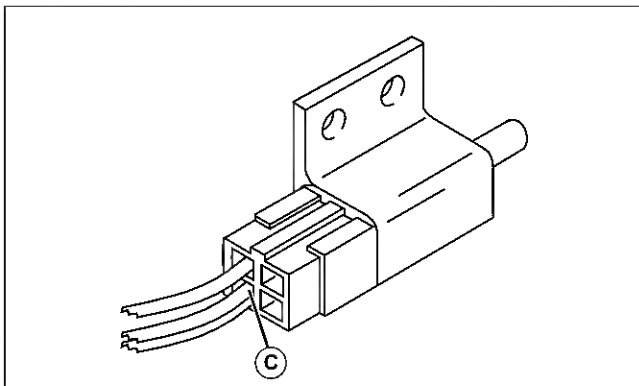


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2. Does voltage at the interlock module connector 805B Pnk wire (B) drop to less than 0.5 volts when the reverse pedal is depressed?

Yes: Check the 501/502-series Blu wires and connections for a short to a battery voltage. If ok, replace the interlock module.

No: Go to next step.



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3. Is battery voltage present at the reverse switch 400D and -E Yel wires (C)?

Yes: Check the 805A and -B Pnk wires and connections. If OK, test the reverse switch. See "Reverse Switch Test and Adjustment" on page 357.

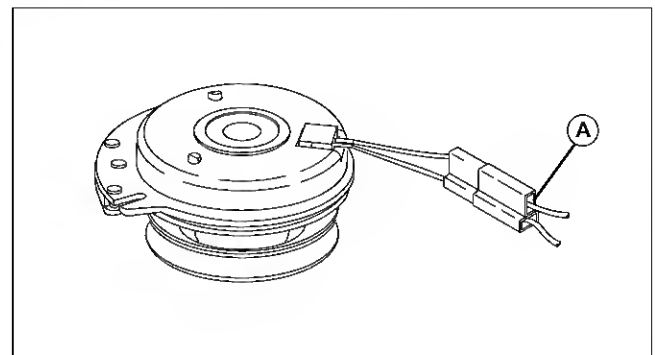
No: Check switched power circuit. See "Power Circuit Diagnostics" on page 278.

## Test Procedure C:

### Test Conditions:

- Brake unlocked.
- Operator on seat.
- Key switch On, engine not running.
- PTO/RIP switch pulled up from On position to momentary position,
- then -
- Reverse pedal depressed (transmission moved to reverse) for each test.

### Momentary Circuit:



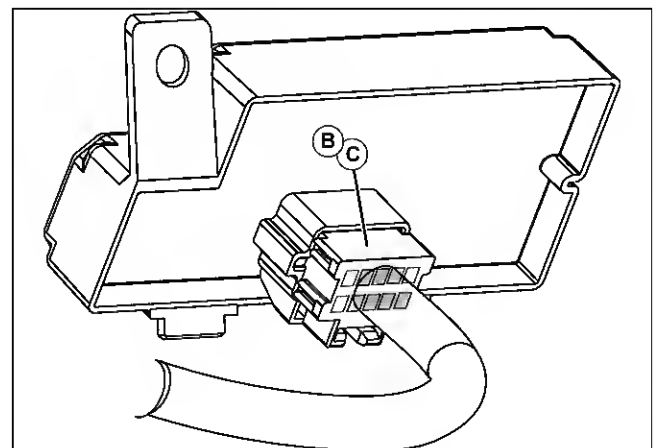
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1. Does the battery voltage remain present at the PTO clutch connector X7, 501A Blu wire (A) when the S5 PTO/RIP switch is pulled up to the momentary position and then the reverse pedal is depressed?

Yes: PTO clutch momentary circuit is functional. Ensure that there is continuity to ground over 100D Blk wire.

No: Verify that the PTO/RIP switch is pulled-up and held before and until the reverse pedal is depressed. Go to next step.

No: Recheck Reverse Shutoff circuit.



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2. Is battery voltage present at the interlock module connector 370B Gry wire (B) and 301 Grn wire (C) when the PTO/RIP switch is pulled up to the momentary position?

Yes: Replace A1 interlock module.

No: Check power circuit. See "Power Circuit Diagnostics" on page 278.

No: Check the 370B Gry wire and connections. If OK, test the PTO/RIP switch. See "PTO/RIP Switch Test" on page 353.

No: Check the 301 Grn wires and connections. If OK, test the PTO/RIP switch. See "PTO/RIP Switch Test" on page 353.

### Headlight Circuit Operation

#### Function:

To provide power to the headlights for illumination if desired by the operator.

#### Operating Conditions

- Key switch in ON with lights position

#### Theory of Operation:

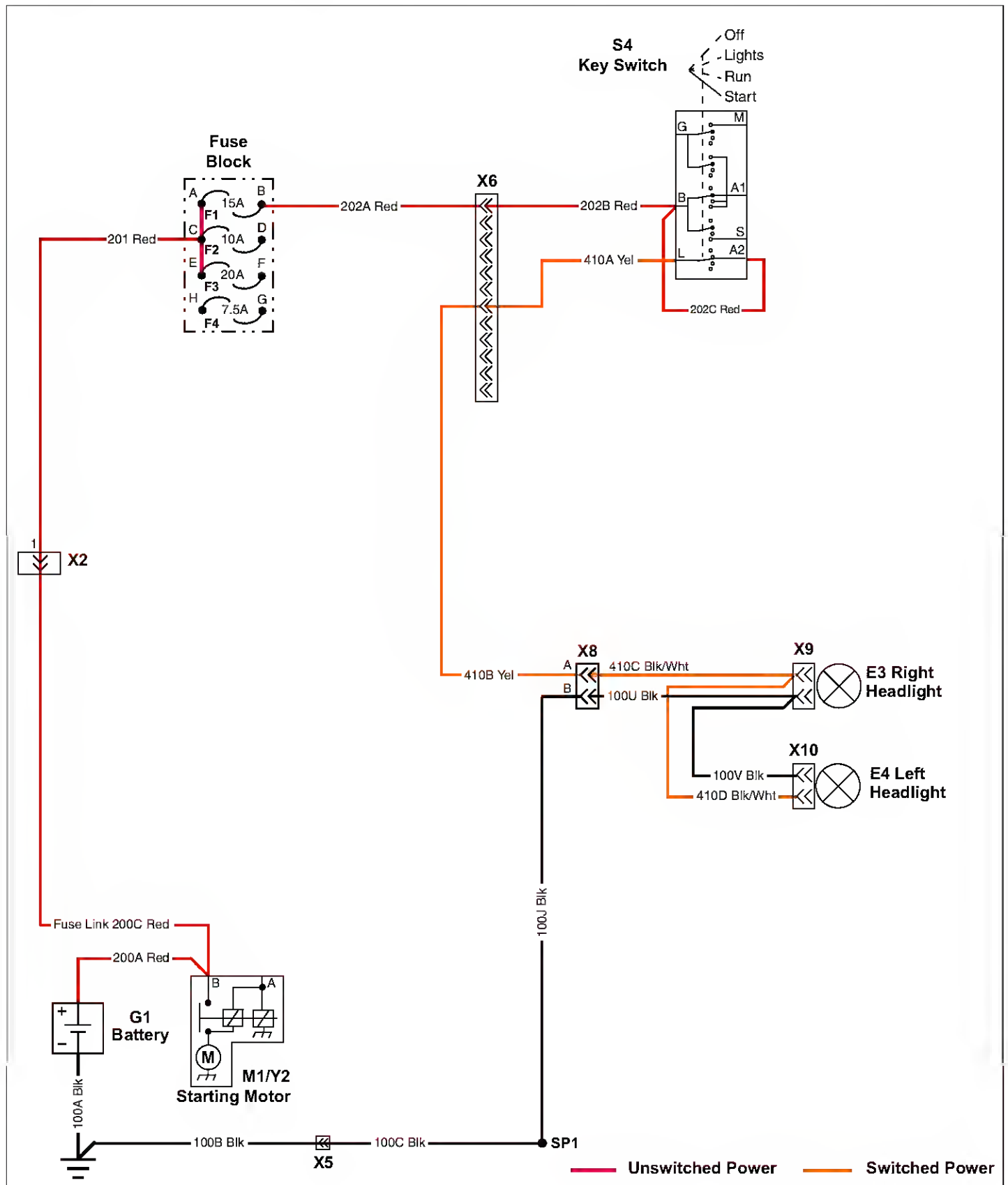
The unswitched power circuit provides power to the S4 key switch. See "Power Circuit Operation" on page 275.

With the S4 key switch in the ON with lights position, current flows from the switch, over the 410A and 410B Yel wires, to the X8 headlight wiring harness connector.

The ground circuit provides a path to ground for the headlights on the 100U Blk (RH headlight), 100V Blk (LH headlight), 100J, -C and -B Blk wires to the W1 frame ground.

# ELECTRICAL THEORY OF OPERATION (SN 040001-)

## Headlight Circuit Wiring Schematic



## Headlight Circuit Diagnostics

### Test Procedure:

#### Test Conditions:

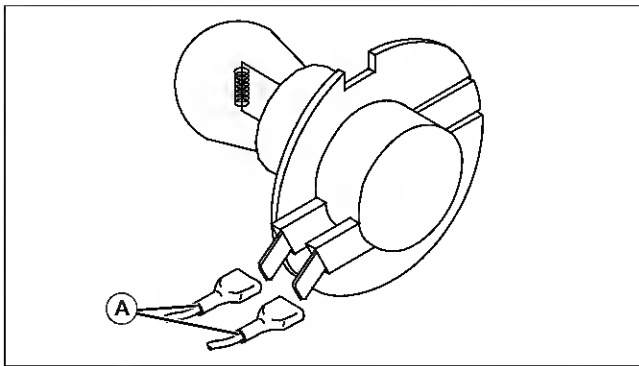
- Key switch turned to on with lights position, engine not running.

#### Headlights:

1. Are both headlights illuminated?

Yes: Circuit is functioning properly.

No: Test the bulb of the light(s) that are not illuminated.  
Go to next step.



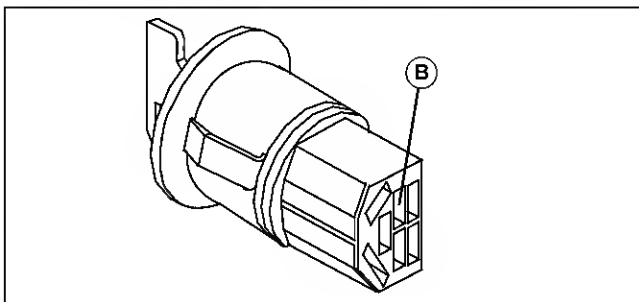
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2. Disconnect the harness from the headlights. Is battery voltage present across the wiring harness connector terminals (A) for each headlight?

Yes: Replace the bulb(s) not illuminated.

No: Check 410C and 410D Blk/Wht wires.

No: Ensure that there is continuity to ground over 100U and 100V Blk wires.



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3. Is battery voltage present at the S4 key switch, 410A Yel wire (terminal L) B)?

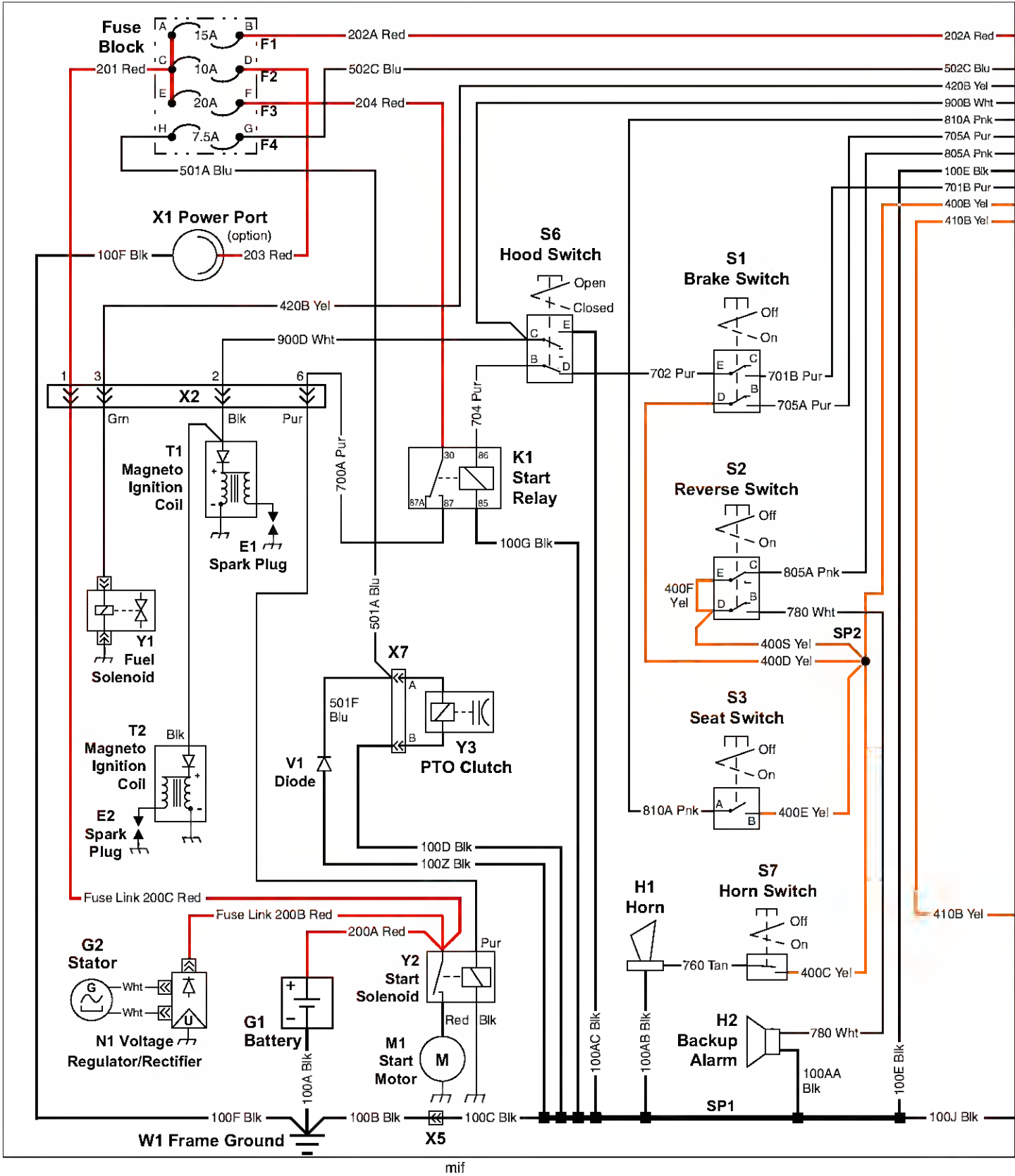
Yes: Check the 410A and -B Yel wires, connector X8.

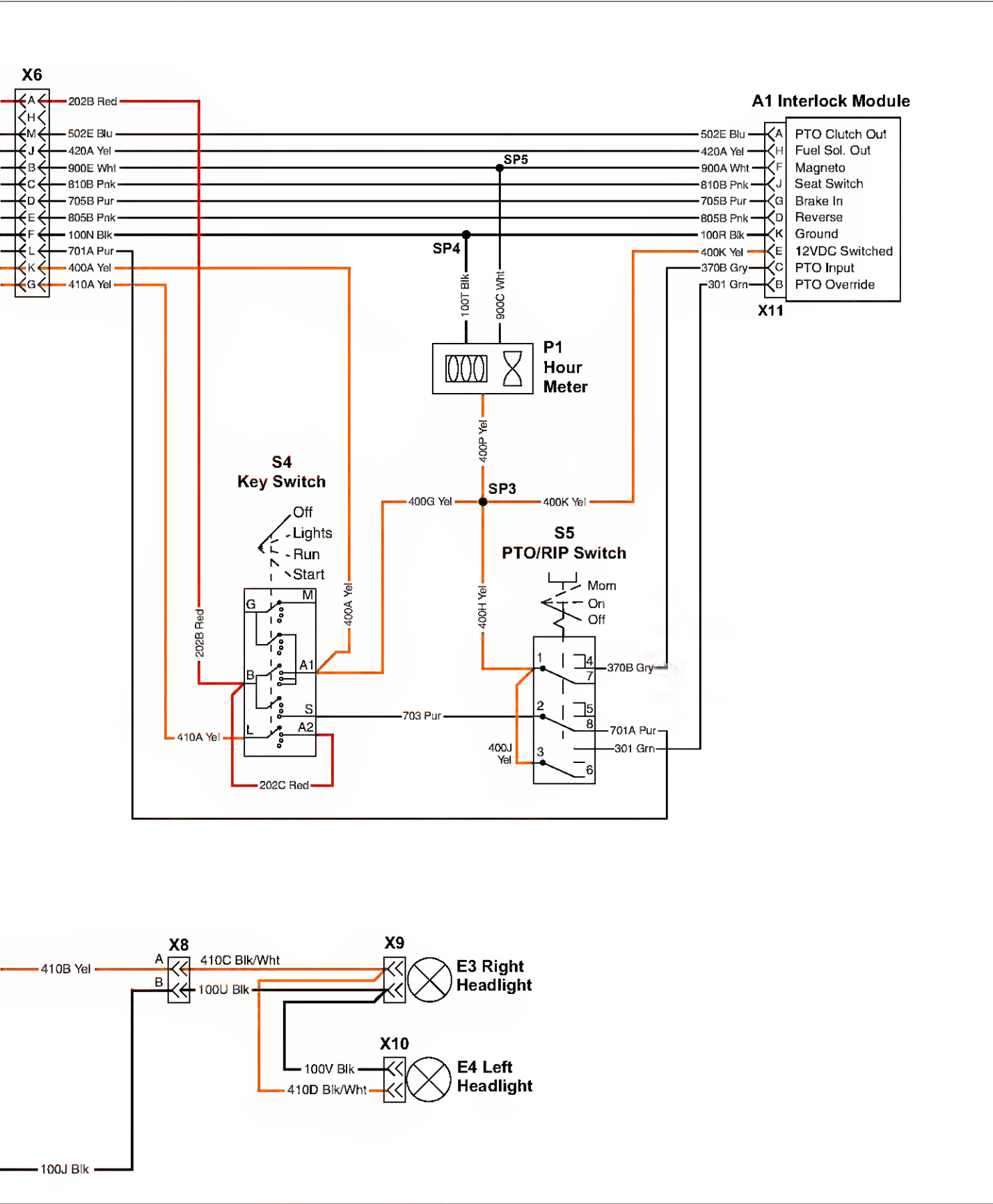
No: Check the power circuit. See "Power Circuit Diagnostics" on page 278.

No: Test the key switch. See "Key Switch Test (SN 040001-)" on page 359.

## Schematics and Harnesses Export (SN 150001-)

### Main Wiring Schematic





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# ELECTRICAL SCHEMATICS AND HARNESSSES EXPORT (SN 150001-)

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## Schematic and Wiring Harness Legend

A1 - Interlock Module  
E1 - Spark Plug  
E2 - Spark Plug  
E3 - Right Headlight  
E4 - Left Headlight  
F1 - Fuse 15A  
F2 - Fuse 10A  
F3 - Fuse 20A  
F4 - Fuse 7.5A  
G1 - Battery  
G2 - Stator  
H1 - Horn  
H2 - Backup Alarm  
K1 - Start Relay  
M1 - Starting Motor  
N1 - Voltage Regulator/Rectifier  
P1 - Hour Meter  
S1 - Brake Switch  
S2 - Reverse Switch  
S3 - Seat Switch  
S4 - Key Switch  
S5 - PTO/RIP Switch  
S6 - Hood Switch  
S7 - Horn Switch  
T1 - Magneto Ignition Coil  
T2 - Magneto Ignition Coil  
V1 - Diode  
W1 - Battery/Frame Ground  
Y1 - Fuel Shutoff Solenoid  
Y2 - Starting Motor Solenoid  
Y3 - PTO Clutch

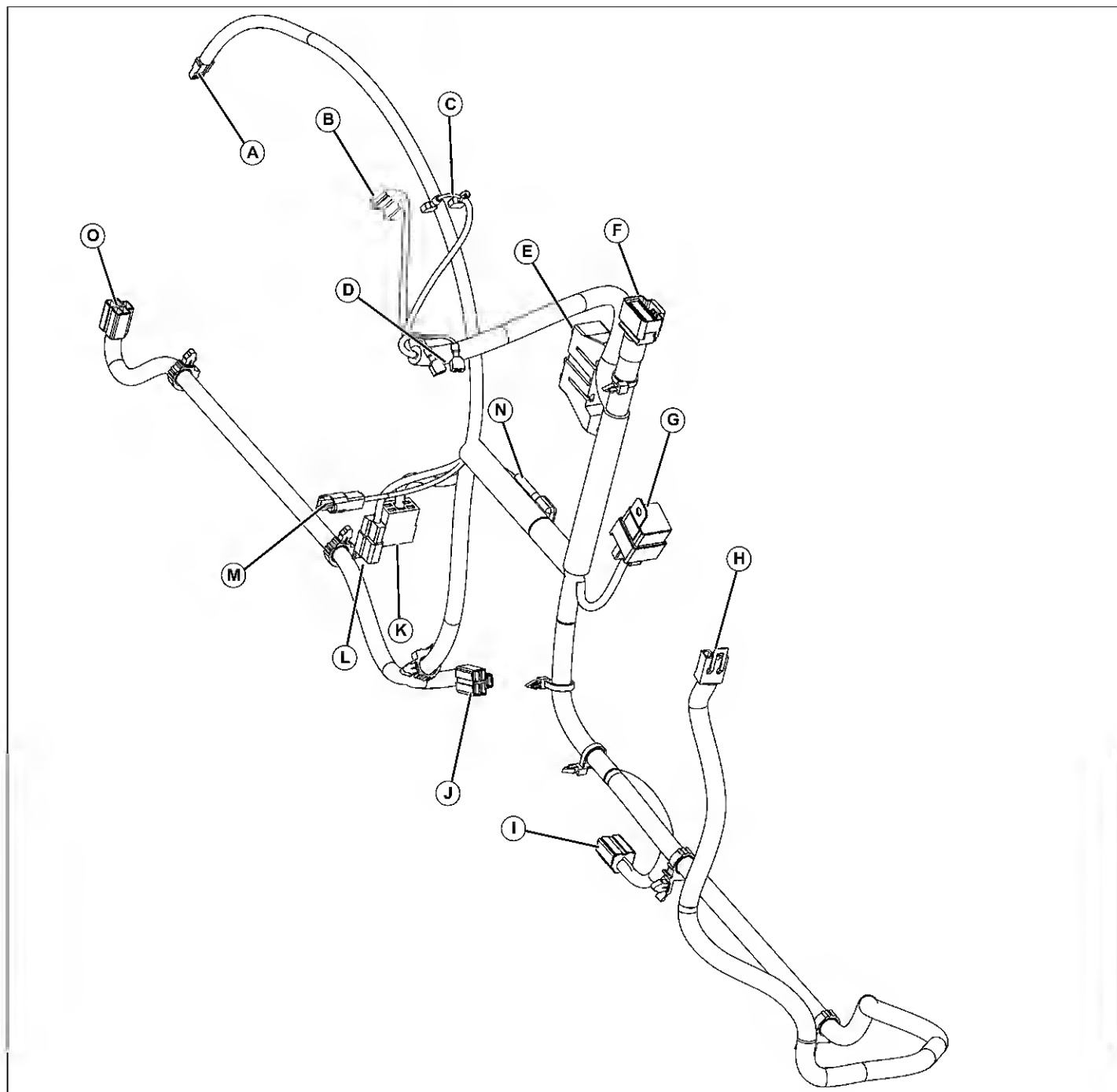
## Connectors:

X1 - Power Port (optional)  
X2 - Main Wiring Harness to Engine  
X5 - Main Wiring Harness to W1 Ground  
X6 - Main Wiring Harness to Control Panel Wiring Harness  
X7 - Main Wiring Harness to PTO Clutch  
X8 - Main Wiring Harness to Headlight Wiring Harness  
X9 - Right Headlight  
X10 - Left Headlight  
X11 - Control Panel Wiring Harness to Interlock Module

## Wiring Harnesses:

W1 - Main Wiring Harness  
W2 - Engine Wiring Harness  
W3 - Control Panel Wiring Harness  
W4 - Headlight Wiring Harness  
W5 - Power Port Wiring Harness (option)

## W1 Main Wiring Harness Component Location



MX43783

A- X8 to W4 Headlight Wiring Harness

B- H2 Backup Alarm

C- H1 Horn

D- S7 Horn Switch

E- Fuse Block

F- X6 to W3 Dash Panel Wiring Harness

G- K1 Start Relay

H- S3 Seat Switch

I- S2 Reverse Switch

J- S1 Brake Switch

K- X2 to W2 Engine Wiring Harness

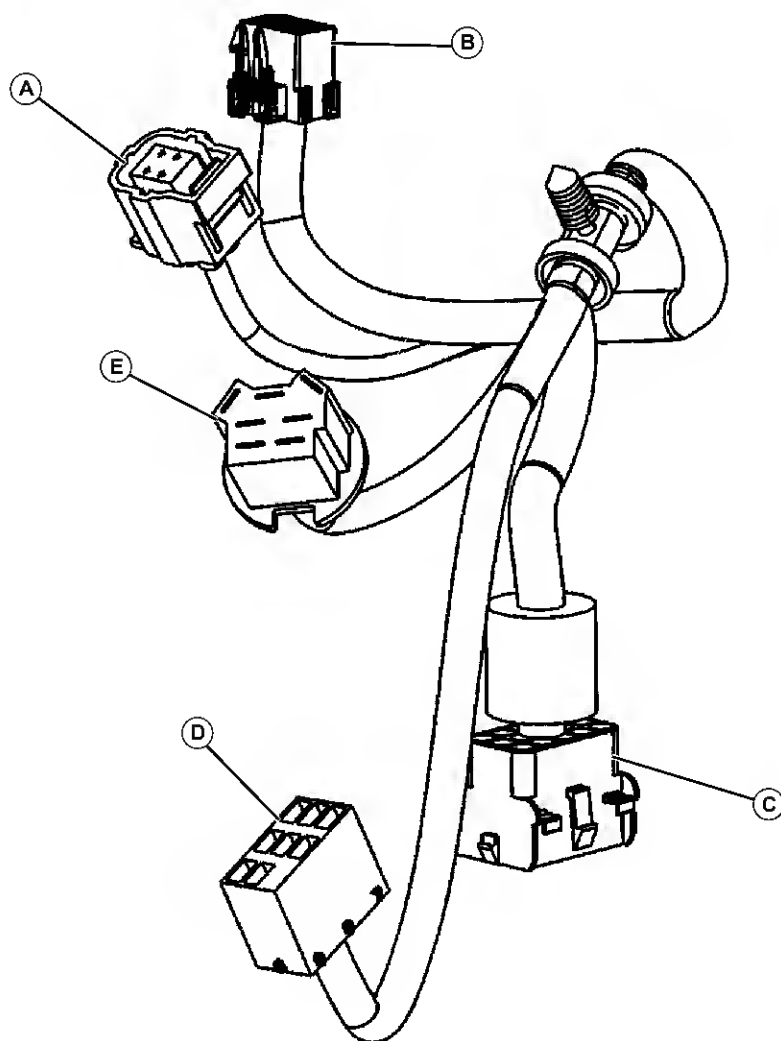
L- X7 to Y3 PTO Clutch

M- X5 Ground Connector

N- V1 Diode

O- S6 Hood Switch

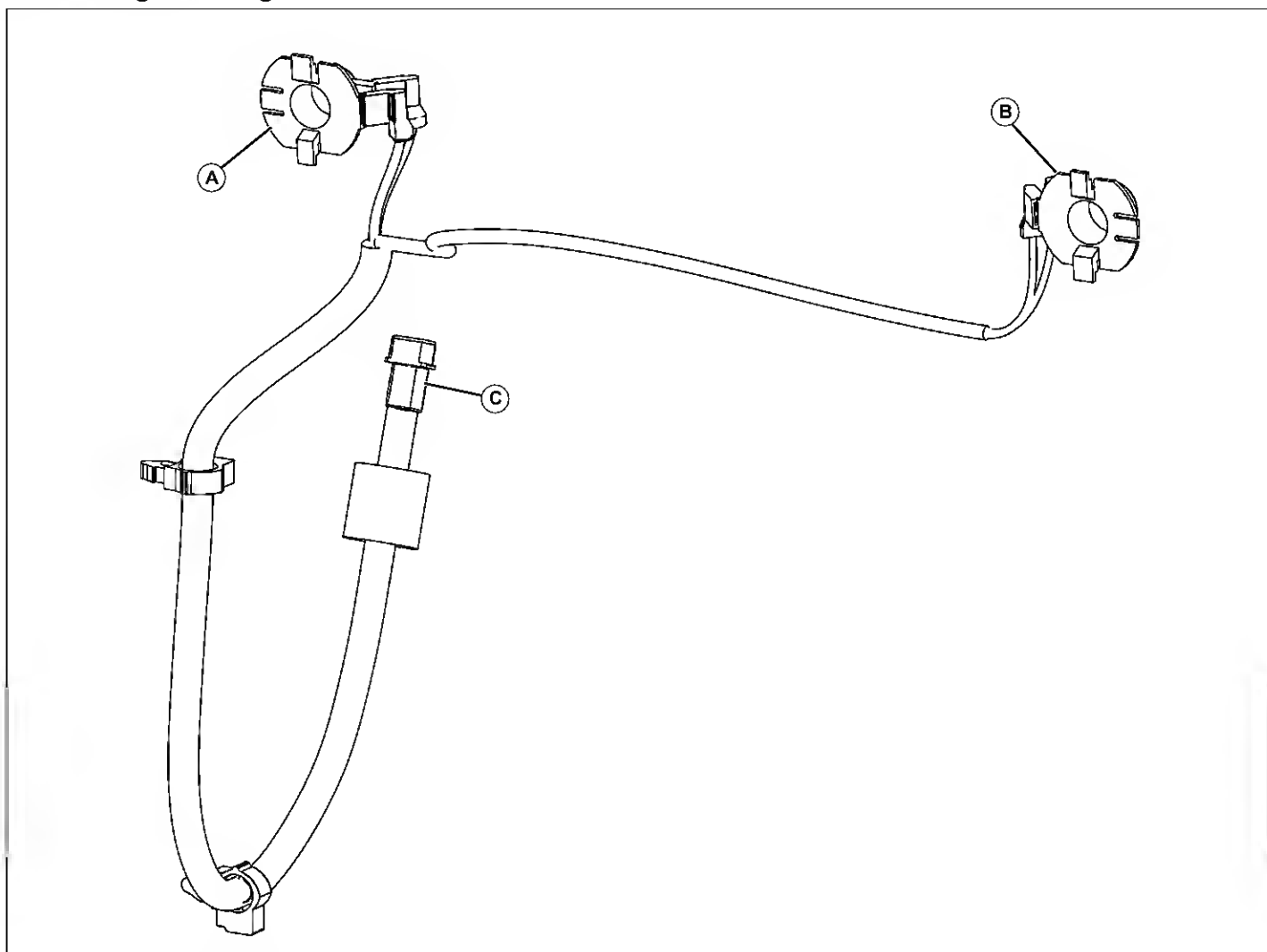
## W3 Control Panel Wiring Harness



MX37972

- A- P1 Hour Meter
- B- X11 to A1 Interlock Module
- C- X6 to W1 Main Wiring Harness
- D- S5 PTO/RIP Switch
- E- S4 Key Switch

## W4 Headlight Wiring Harness



MX37988

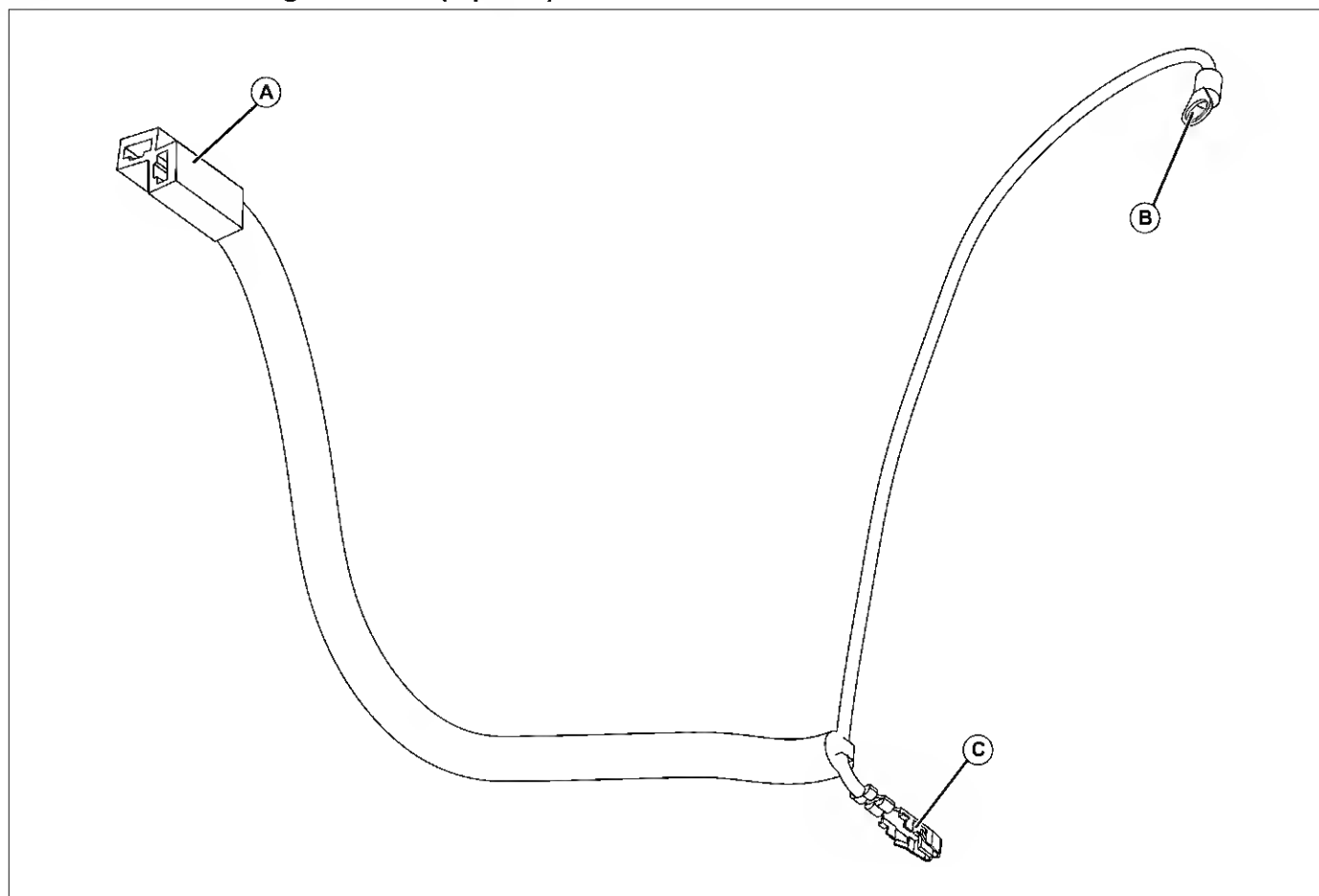
A- X9 to E3 Right Headlight

B- X10 to E4 Left Headlight

C- X8 to W1 Main Wiring Harness

# ELECTRICAL SCHEMATICS AND HARNESSSES EXPORT (SN 150001-)

## W5 Power Port Wiring Harness (Option)



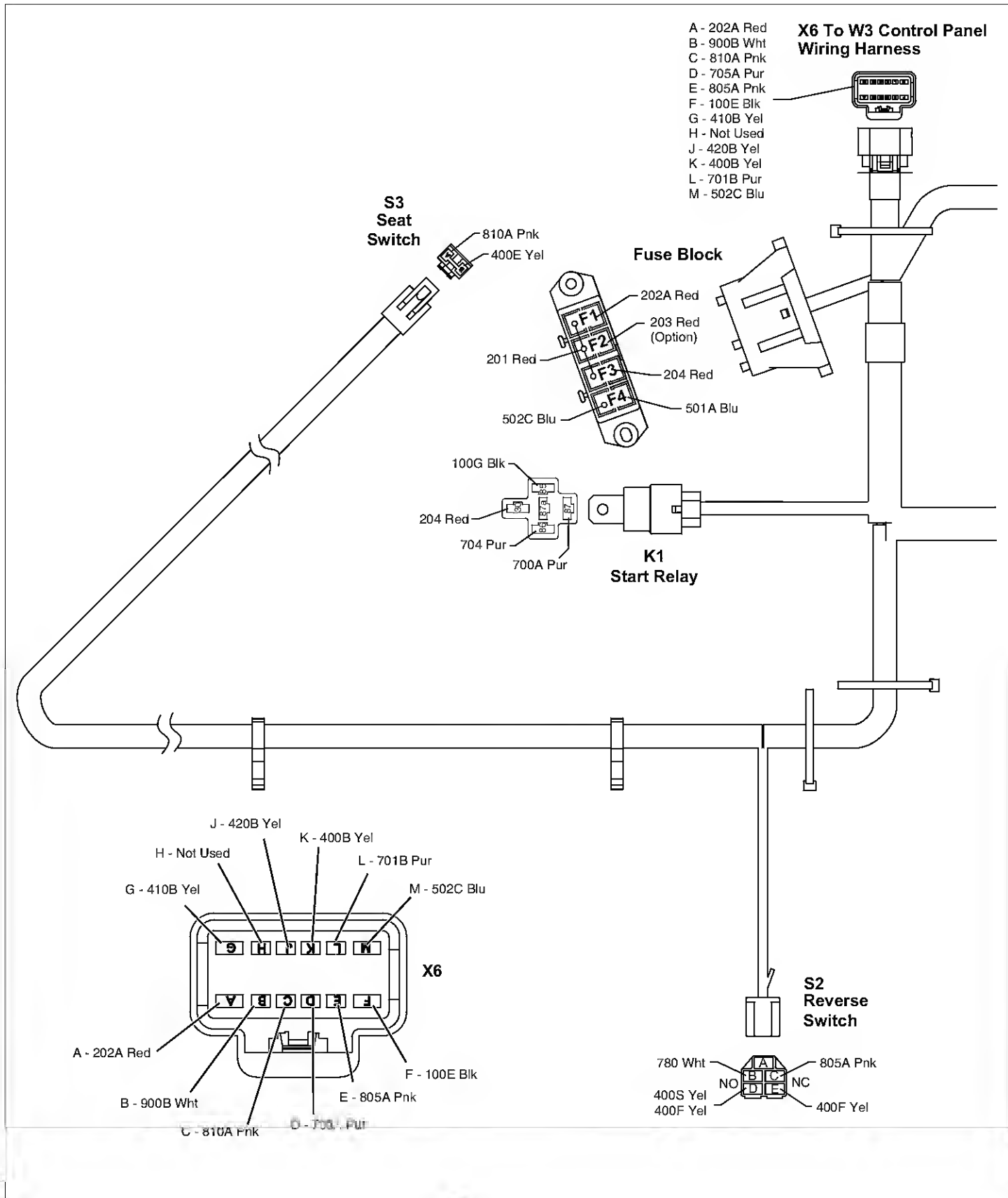
MX38476

- A- X1 to Power Port
- B- To Machine Ground
- C- To F2 Fuse

# ELECTRICAL SCHEMATICS AND HARNESSES EXPORT (SN 150001-)

## W1 Main Wiring Harness

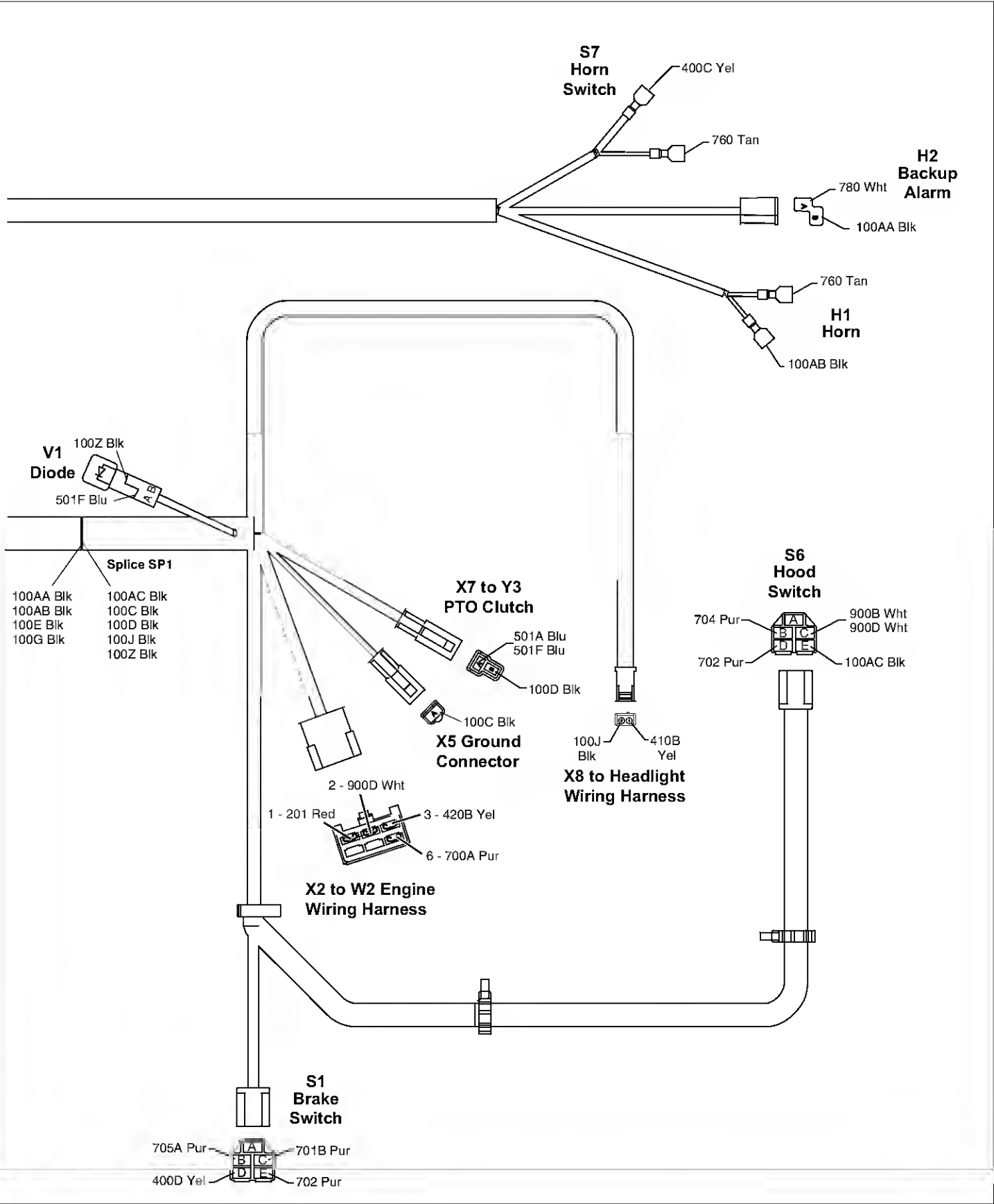
Harness (1 of 2)



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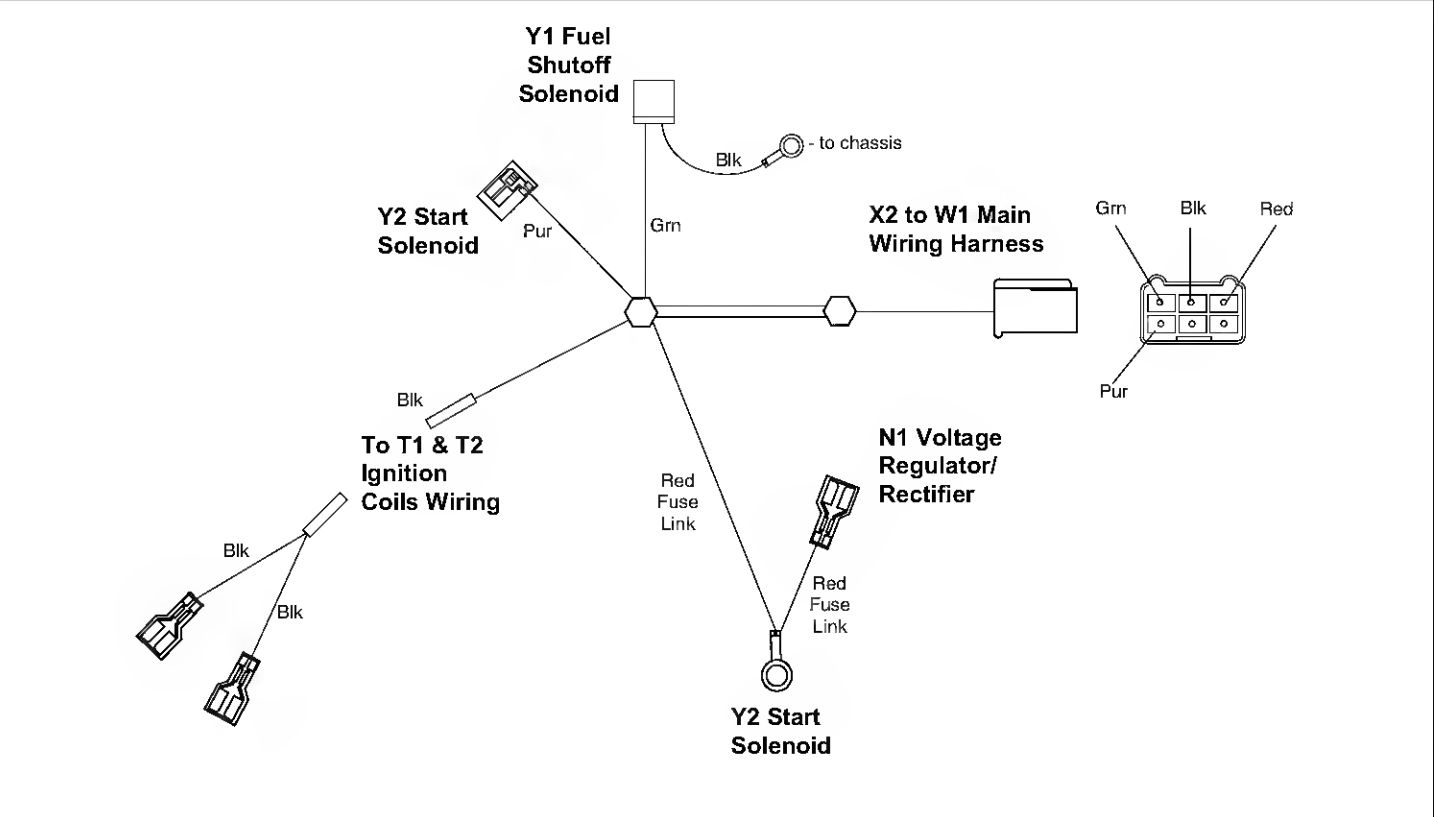
ELECTRICAL SCHEMATICS AND HARNESSES EXPORT (SN 150001-)

Harness (2 of 2)



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W2 Engine Wiring Harness



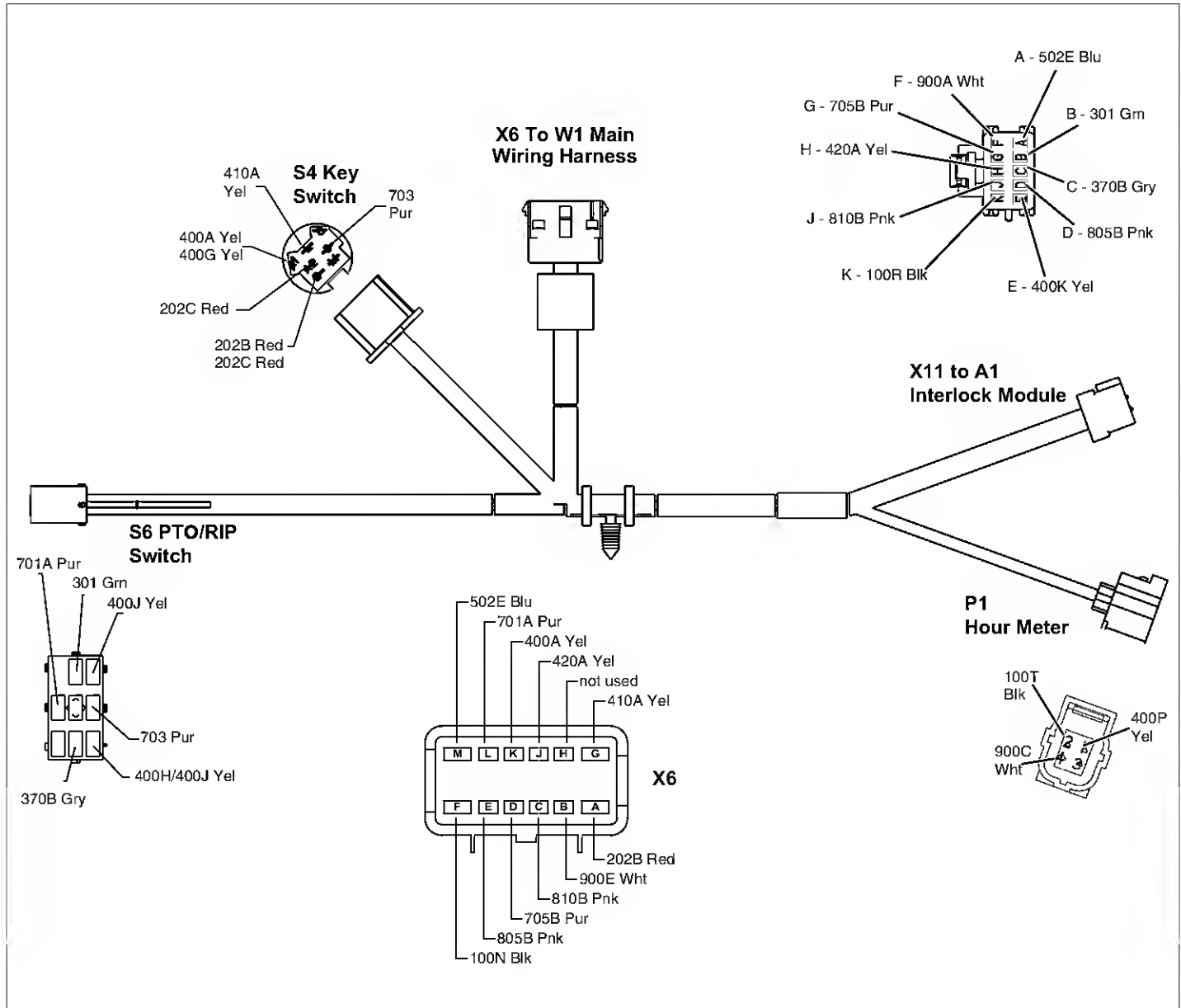
W2 Engine Wiring Harness Color Codes

Size/No./Color	Wire Connection Points
13.0 100A Blk	G1, W1 Ground
3.0 100B Blk	W1 Ground, X5
13.0 200A Red	G1, Y2
3.0 200B Red	Y2, N1
3.0 200C Red	Y2, X2
1.0 Grn	Y1, X2
1.0 Blk	(T1 & T2), X2
1.0 Pur	X2, Y2



# ELECTRICAL SCHEMATICS AND HARNESSES EXPORT (SN 150001-)

## W3 Control Panel Wiring Harness



MIF/MX37975/MX38485/MX38486

### W3 Control Panel Wiring Harness Color Codes (Export)

Size/No./Color	Wire Connection Points	Size/No./Color	Wire Connection Points
		0.8 301 Grn	S5 (Pin 6), A1 (Pin B)
		0.8 370B Gry	S5 (Pin 4), A1 (Pin C)
		2.0 400A Yel	X6 (Pin K), S4 (Pin A1)
		1.0 400G Yel	S4 (Pin A1), Splice (SP3)
		1.0 400H Yel	Splice (SP3), S5 (Pin 1)
		1.0 400J Yel	S5 (Pin 1), S5 (Pin 3)
		1.0 400K Yel	Splice (SP3), A1 (Pin E)
		1.0 400P Yel	Splice (SP3), P1 (Pin A)
1.0 100N Blk	X6 (Pin F), Splice (SP4)		
1.0 100R Blk	Splice (SP4), A1 (Pin K)		
0.8 100T Blk	Splice (SP4), P1 (Pin B)		
2.0 202B Red	X6 (Pin A), S4 (Pin B)		
1.0 202C Red	S4 (Pin B), S4 (Pin A2)		

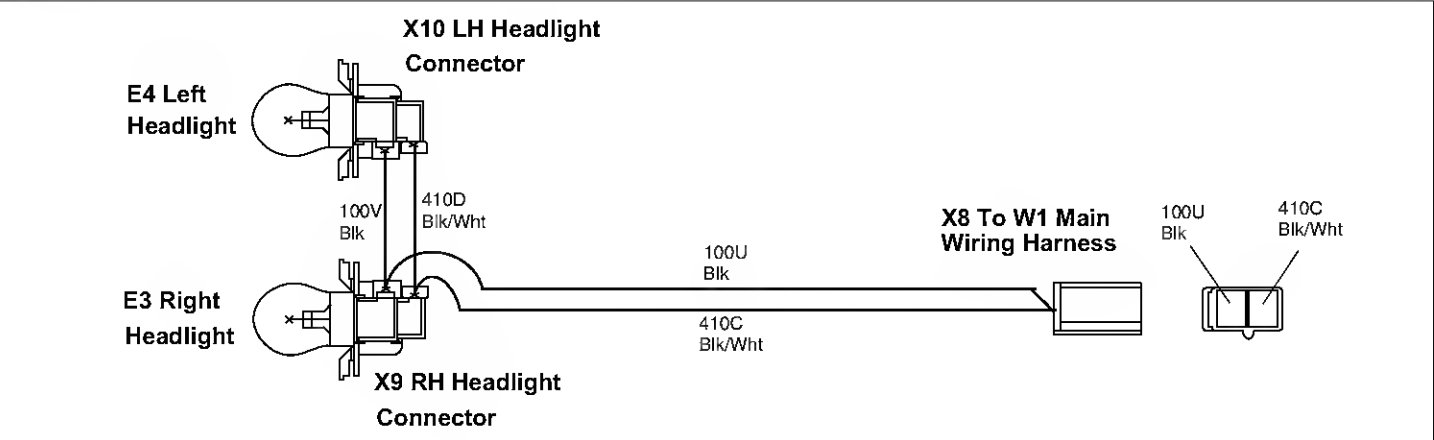
# ELECTRICAL SCHEMATICS AND HARNESSES EXPORT (SN 150001-)

Size/No./Color	Wire Connection Points	Size/No./Color	Wire Connection Points
1.0 410A Yel	X6 (Pin G), S4 (Pin L)	0.8 400E Yel	Splice (SP2), S3 (Pin B)
0.8 420A Yel	X6 (Pin J), A1 (Pin H)	0.8 400F Yel	S2 (pin D), S2 (pin E)
0.8 502E Blu	X6 (Pin M), A1 (Pin A)	0.8 400S Yel	S2 (Pin D), Splice (SP2)
0.8 701A Pur	X6 (Pin L), S5 (Pin 8)	0.8 410B Yel	X6 (Pin G), X8 (Pin A)
1.0 703 Pur	S4 (Pin S), S5 (Pin 2)	0.8 420B Yel	X2 (Pin 3), X6 (Pin J)
0.8 705B Pur	X6 (Pin D), A1 (Pin G)	1.0 501A Blu	F4, X7 (Pin A)
0.8 805B Pnk	X6 (Pin E), A1 (Pin D)	0.8 501F Blu	V1, X7 (Pin A)
0.8 810B Pnk	X6 (Pin C), A1 (Pin J)	1.0 502C Blu	F4, X6 (Pin M)
0.8 900A Wht	Splice (SP5), A1 (Pin F)	1.0 700A Pur	X2 (Pin 6), K1 (Pin 87)
0.8 900C Wht	Splice (SP5), P1 (Pin C)	0.8 701B Pur	S1 (Pin C), X6 (Pin L)
0.8 900E Wht	X6 (Pin B), Splice (SP5)	0.8 702 Pur	S6 (Pin D), S1 (Pin E)

## W1 Main Wiring Harness Color Codes

Size/No./Color	Wire Connection Points	Size/No./Color	Wire Connection Points
3.0 100C Blk	X5, Splice (SP1)	0.8 780 Wht	S2 (Pin B), H2
1.0 100D Blk	Splice (SP1), X7 (Pin B)	0.8 805A Pnk	S2 (Pin C), X6 (Pin E)
1.0 100E Blk	Splice (SP1), X6 (Pin F)	0.8 810A Pnk	S3 (Pin A), X6 (Pin C)
2.0 100F Blk (Optional)	X1, W1 Ground	0.8 900B Wht	X6 (Pin B), S6 (Pin C)
0.8 100G Blk	K1 (Pin 85), Splice (SP1)	0.8 900D Wht	X2 (Pin 2), S6 (Pin C)
1.0 100J Blk	Splice (SP1), X8 (Pin B)		
0.8 100Z Blk	Splice (SP1), V1		
0.8 100AA Blk	Splice (SP1), H2		
0.8 100AB Blk	Splice (SP1), H1		
0.8 100AC Blk	Splice (SP1), S6 (Pin E)		
5.0 201 Red	X2 (Pin 1), F2 (buss)		
2.0 202A Red	F1, X6 (Pin A)		
2.0 203 Red (Optional)	F2, X1		
1.0 204 Red	F3, K1 (Pin 30)		
0.8 400B Yel	Splice (SP2), X6 (Pin K)		
0.8 400C Yel	Splice (SP2), S7		
0.8 400D Yel	Splice (SP2), S1 (Pin D)		

W4 Headlight Wiring Harness



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W5 Power Port Wiring Harness (Option)



MIF

W4 Headlight Wiring Harness Color Codes

Size/No./Color	Wire Connection Points
0.8 100U Blk	X8, X9
0.8 100V Blk	X9, X10
0.8 410C Blk/Wht	X8, X9
0.8 410D Blk/Wht	X9, X10

# ELECTRICAL THEORY OF OPERATION EXPORT (SN 150001-)

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## Theory of Operation Export (SN 150001-)

### Power Circuit Operation

#### Function:

To provide power to the primary electrical components whenever the battery is properly connected. Power is distributed by the unswitched, switched (key switch in On position) and secondary power circuits. When switched on, the A1 interlock module provides the current to the secondary power circuit. Secondary power is removed should the A1 interlock module fail.

#### Operating Conditions, Unswitched Circuits:

Voltage must be present at the following components with the key switch in the Off position.

- G1 battery positive terminal
- N1 voltage regulator/rectifier
- Y2 start solenoid
- F1, F2 and F3 fuses
- S4 key switch - B and A2 terminals
- X1 power port (optional)
- K1 start relay - terminal 30

The positive cable of both the battery and the N1 voltage regulator/rectifier connect to the main terminal of the Y2 start solenoid. This terminal is used as the 12 volt DC tie point for the rest of the electrical system. Fuse link 200C and the 201 Red wire supply voltage the F1, F2 and F3 fuses. Fuse F1 protects the circuit to the key switch; fuse F2 protects the power port circuit; fuse F3 protects the K1 start relay. Fuse link 200B connects the N1 voltage regulator to the system. The battery cables and the regulator/rectifier tie point connections must be in good order for the machine's electrical system to work properly. For proper starting motor operation, the battery cables must carry high currents. The ground cable connection is equally as important as the positive cable connection in maintaining electrical system integrity.

#### Operating Conditions, Switched Circuits:

Switched power is controlled by the key switch. With the key switch in On position, PTO/RIP switch Off, brake unlocked, transmission in neutral, and operator off the seat, switched voltage should be present at the following components:

- S1 brake switch - 400D Yel wire
- S2 reverse switch - 400S and 400F jumper Yel wires
- S3 seat switch - 400E Yel wire
- S4 key switch - terminals L (lights On position) and A1

- S5 PTO/RIP switch - 400H and 400J jumper Yel wires
- S7 horn switch - 400C Yel wire
- A1 interlock module - terminal E, 400K Yel wire
- A1 interlock module - terminal D, 805B Pnk wire
- P1 hour meter - 400P Yel wire

With power now available to the various components, the electrical system is ready to start and run the engine, operate the PTO clutch and system interlocks, and light the head lamps.

The ground circuit is equally important as the power circuit. Good wires and connections are needed to efficiently operate the various electrical components.

#### Operating Conditions, Secondary Switched Circuits:

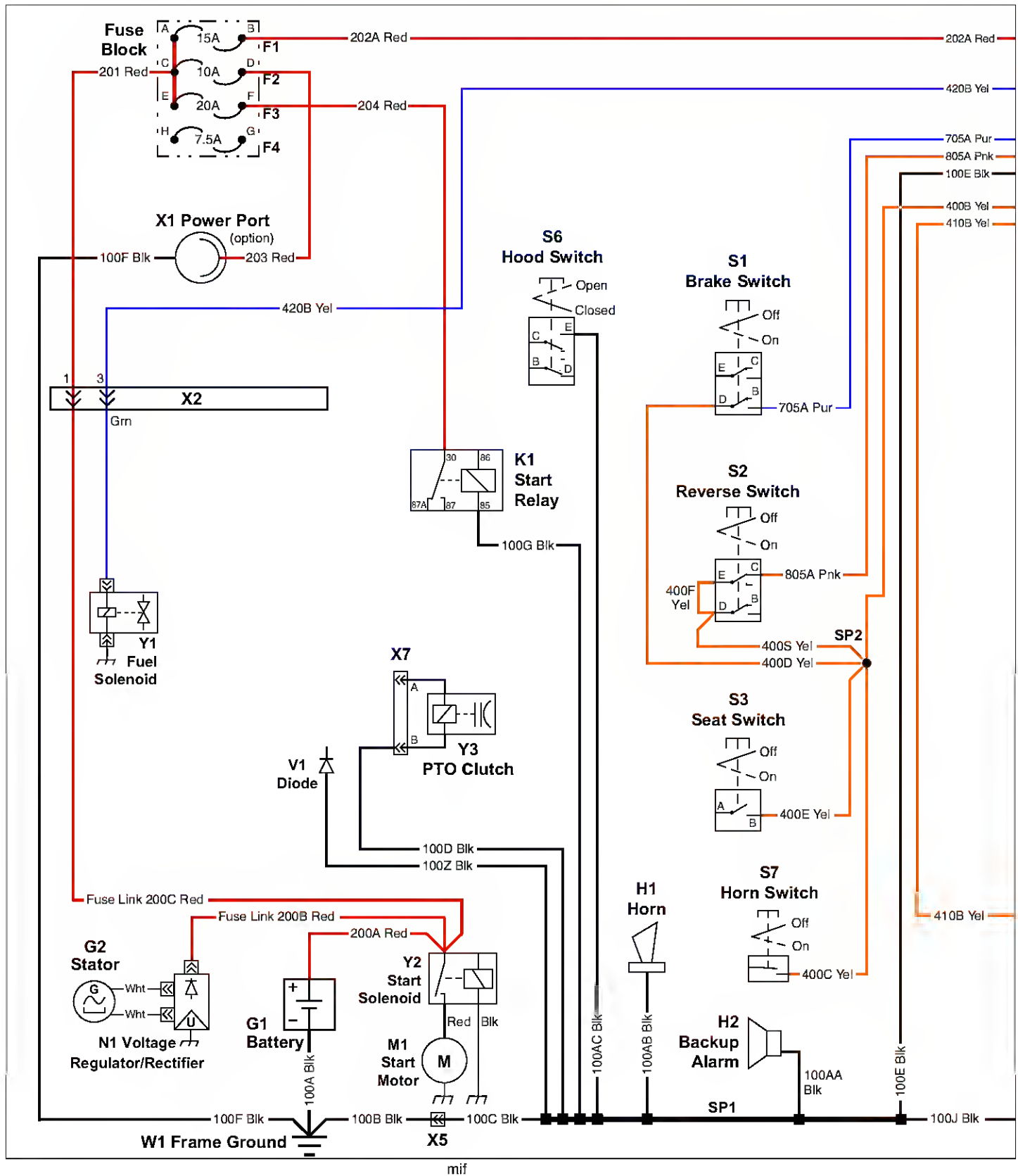
Secondary switched voltage must be present at these components during the following conditions: Key switch in On position, transmission in neutral, PTO/RIP in Off position, brake locked, and operator off seat:

- Y1 fuel shutoff solenoid - Grn wire on engine harness, 420-series Yel wires

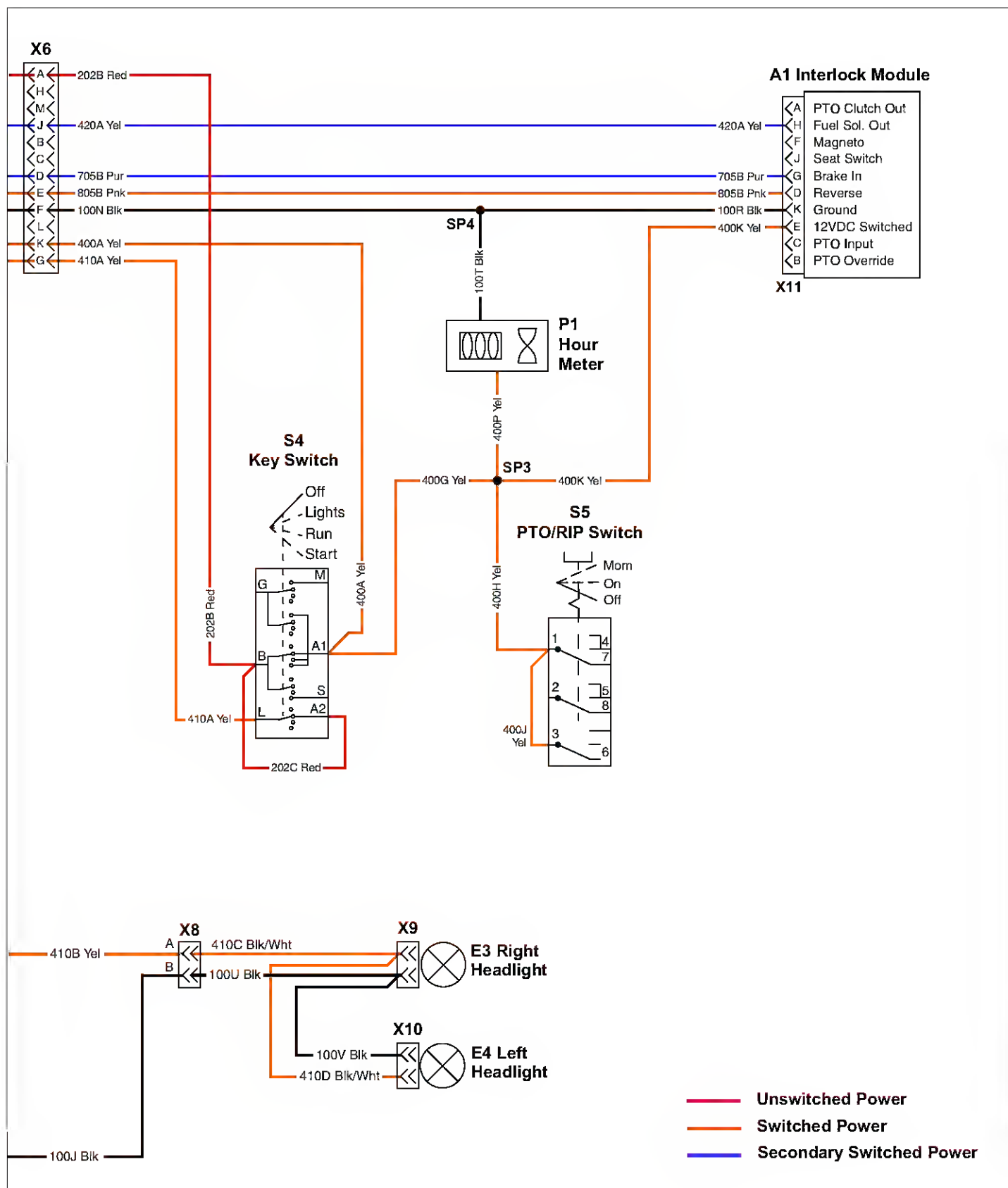
These circuits are controlled by the A1 interlock module.

# ELECTRICAL THEORY OF OPERATION EXPORT (SN 150001-)

## Power Circuit Wiring Schematic (Shown with Lights On)



# ELECTRICAL THEORY OF OPERATION EXPORT (SN 150001-)



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# ELECTRICAL THEORY OF OPERATION EXPORT (SN 150001-)

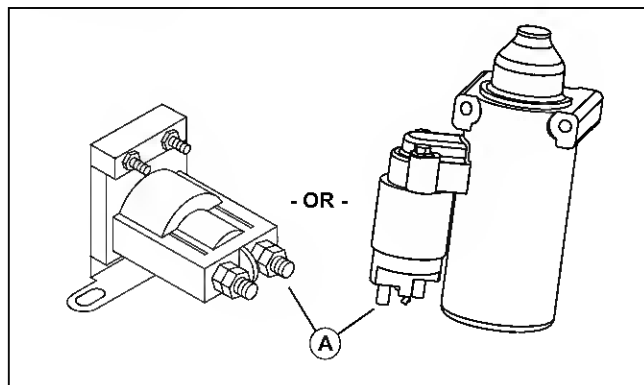
## Power Circuit Diagnostics

### Test Procedure A:

#### Test Conditions:

- Battery properly connected.
- Key switch off.

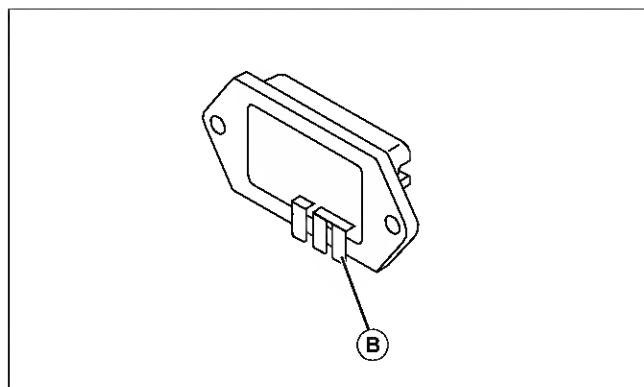
#### Unswitched Power:



1. Is battery voltage present at the starting motor solenoid 200A Red wire (A)?

Yes: Go to next step.

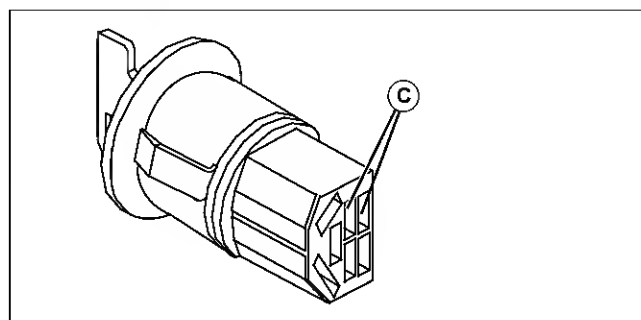
No: Check the battery connections. If ok, test the battery. See "Battery Test" on page 343.



2. Is battery voltage present at the N1 voltage regulator/rectifier 200B Red wire (B)?

Yes: Go to next step.

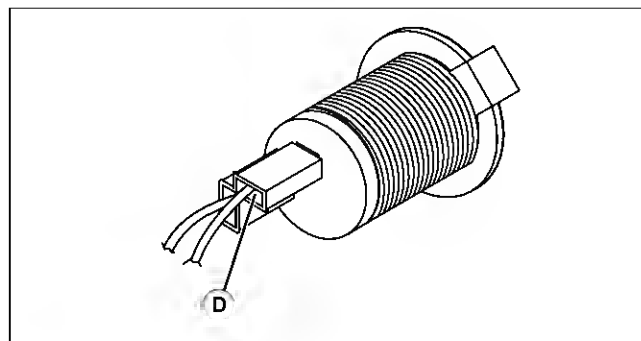
No: Test the 200B Red fuse link.



3. Is battery voltage present at the S4 key switch, 202B Red wire (terminals B and A2) (C)?

Yes: Go to next step.

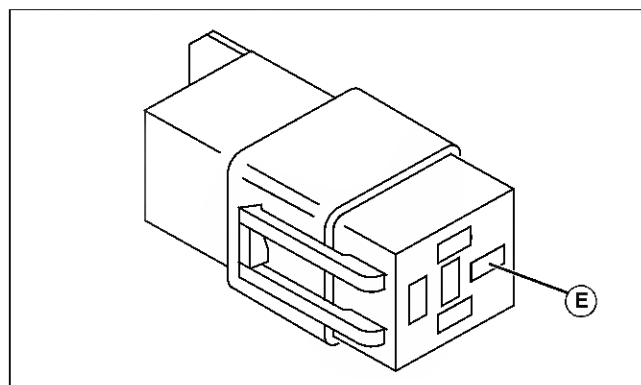
No: Check 200C Red fuse link, X2 connector 201 Red wire, F1 fuse, 202A Red wire, X6 connector, and 202B Red wire and connections.



4. Is battery voltage present at the (optional) power port (D)?

Yes: Go to next step.

No: Check F2 fuse. Check the 203 Red wire and connections.



5. Is battery voltage present at K1 start relay, 204 Red wire (terminal 30) (E)?

Yes: Go to next procedure.

No: Check F3 fuse, 204 Red wire and connections.

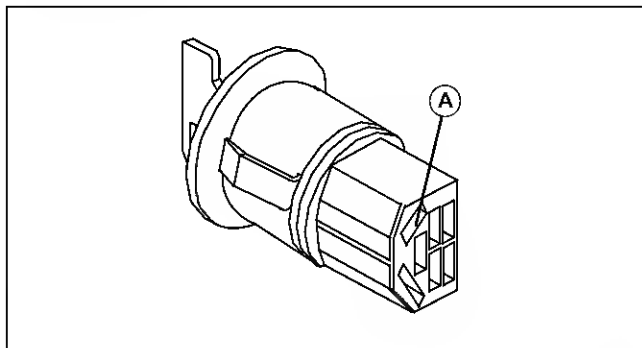
# ELECTRICAL THEORY OF OPERATION EXPORT (SN 150001-)

## Test Procedure B:

### Test Conditions:

- Key switch to On position.
- Transmission in neutral (reverse switch closed).
- All other switches off.

### Switched Power:

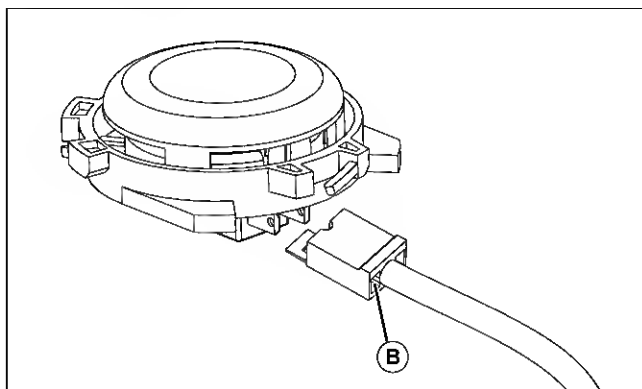


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1. Is battery voltage present at the S4 key switch, 400A Yel wire (terminal A1) (A)?

Yes: Go to next step.

No: Test key switch. See "Key Switch Test (SN 040001-)" on page 359.

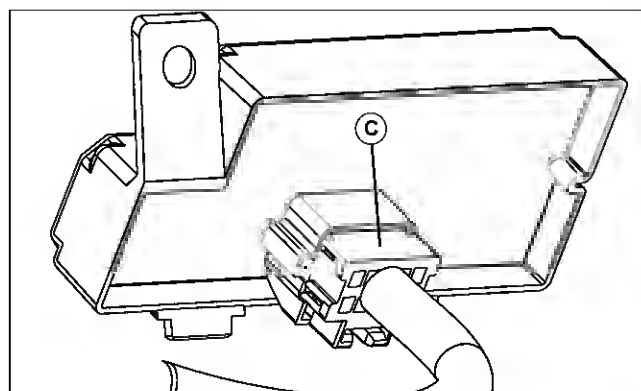


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2. Is battery voltage present at the S3 seat switch, 400E Yel wire (B)?

Yes: Go to next step.

No: Check 400A, -B and -E Yel wires, X6 connector, splice SP2 and connections.

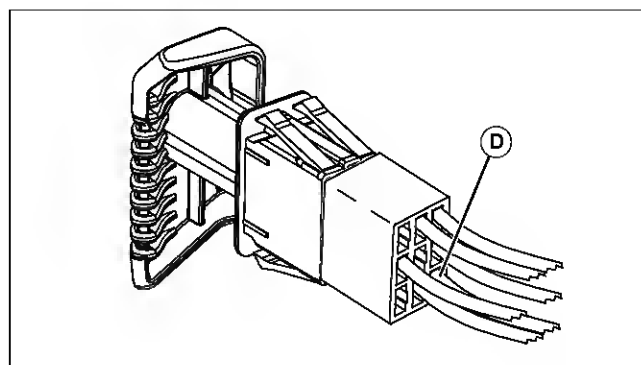


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3. Is battery voltage present at the interlock module connector X11, 805B Pnk wire (C)?

Yes: Go to next step.

No: Check 805B and -A Pnk wires, X6 connector. Check for voltage at the reverse switch 400S and -F Yel wires. If OK, test reverse switch. See "Reverse Switch Test and Adjustment" on page 357.

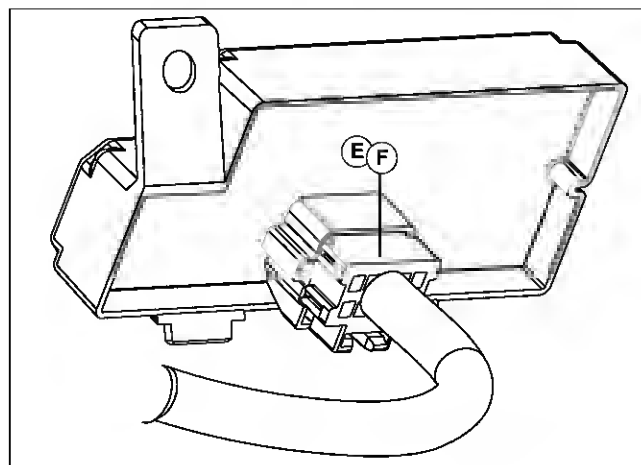


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4. Is battery voltage present at the PTO/RIP switch, 400H Yel wire (terminal 1) (D)?

Yes: Go to next step.

No: Check 400G and 400H Yel wires and connections.



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5. Is battery voltage present at the interlock module 400K Yel wire (E)?

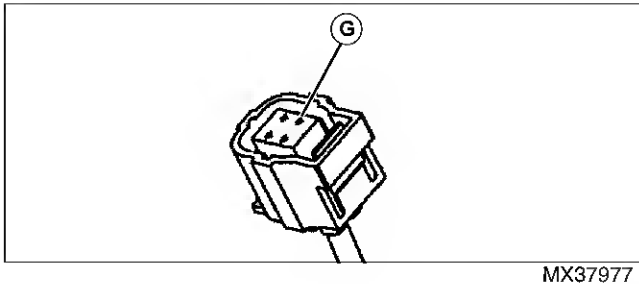
Yes: Go to next step.

No: Check 400E and 400K Yel wires and connections.

6. Is there continuity between interlock module 100R Blk wire (F) and ground?

Yes: Test complete.

No: Check 100R Blk wire, X6 connector, 100E and 100C Blk wires, X5 connector, and 100B Blk wire.



7. Is battery voltage present at P1 hour meter, 400P Yel wire (G)?

Yes: Ensure that there is continuity to ground over 100T Blk wire. If OK, power circuit checks complete. See specific circuit diagnosis if problems persist.

No: Check 400G, and 400P Yel wires and connections.

## Cranking Circuit Operation

### Function:

To energize the starting motor solenoid and engage the starting motor to crank the engine.

### Operating Conditions:

- Key switch in Start position.
- Brake locked.
- PTO/RIP switch in Off position.

### Theory of Operation:

The starting motor may be either of the solenoid shift (with integrated solenoid) or inertia style (separate solenoid). The unswitched power circuit provides current to the S4 key switch. Fuse F3 protects the cranking circuit. Power flows from the battery positive (+) terminal to the starter solenoid battery terminal, 200C fuse link, 201 Red wire, F1 fuse, 202A and -B Red wires, to the key switch.

Moving the key switch from the Off position energizes the switched power circuit and A1 interlock module. The module is used to control the fuel shutoff solenoid and magneto primary circuit.

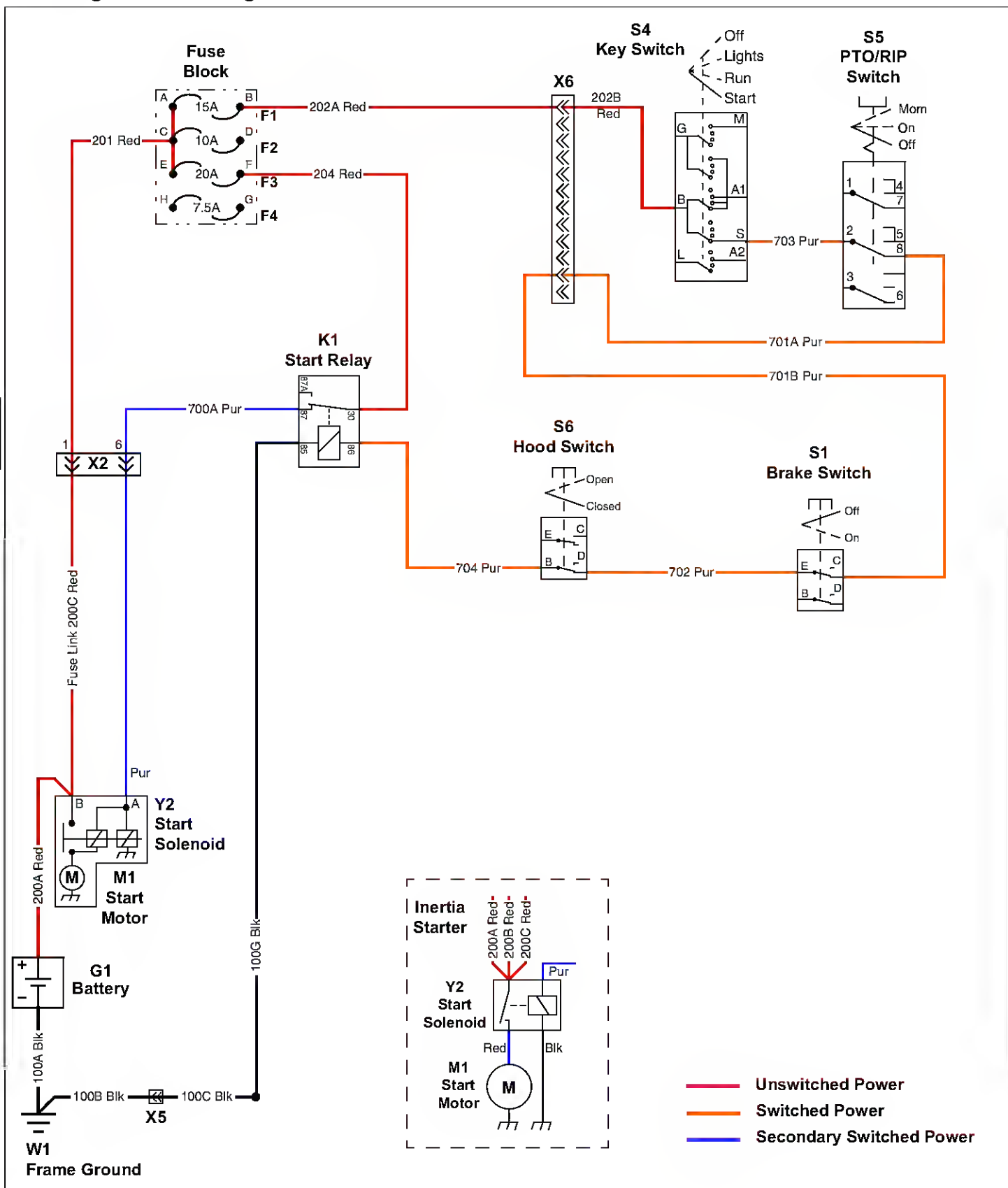
When the S4 key switch is turned to the Start position, the switch "S" terminal powers the 703 Pur wire. With the S5 PTO/RIP switch in the Off position, the 701A Pur wire is then energized. Connector X6 mates wire 701A to wire 701B and the S1 brake switch. With the switch in the closed position (brake on), the 702 Pur wire conducts the power to the S6 hood switch. In the closed position, the hood switch routes the power to the 704 Pur wire and K1 start relay coil. This will energize the relay coil, which is grounded by the 100G wire. The relay contacts close, providing power to the Y2 start solenoid via the 204 Red and 700A Pur wires and the Pur wire of engine wiring harness.

The energized Y2 start solenoid pulls in a plunger. On a solenoid shift motor, the plunger also pushes the starter motor pinion gear forward, engaging the flywheel. The plunger closes the solenoid main contacts. High current from the battery flows through the contacts to the M1 starting motor. An inertia-type motor will engage the flywheel once the starting motor begins to spin.

With the starting motor cranking the engine, the A1 interlock module must receive an input from the brake switch in order to activate the fuel shutoff solenoid (See "Fuel Shutoff Solenoid Circuit Operation" on page 291), as well as open the shunt ground path to the magnetos (See "Ignition Circuit Operation" on page 287). This input circuit uses switched power from the 400D Yel wire, across the brake switch (brake locked), to the 705A and -B Pur wires and the A1 interlock module.

# ELECTRICAL THEORY OF OPERATION EXPORT (SN 150001-)

## Cranking Circuit Wiring Schematic



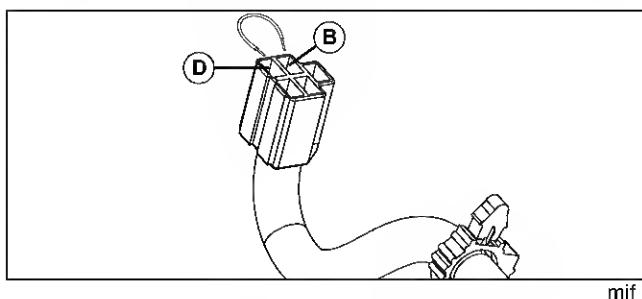
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## Cranking Circuit Diagnostics

### Hood Switch

During normal operation the hood switch must be closed. The circuit can be tested if the hood is removed and the hood switch is manually closed (see "Hood Switch Test" on page 356); or if the hood switch is disconnected and a jumper wire is installed in the switch connector.

1. Remove hood. See "Hood Removal and Installation" on page 563 in the Miscellaneous section.
2. Manually close hood switch:
  - a. Close hood switch by pressing plunger and securing it in place with a tie wrap or tape; or,
  - b. Remove hood switch from wiring harness connector.



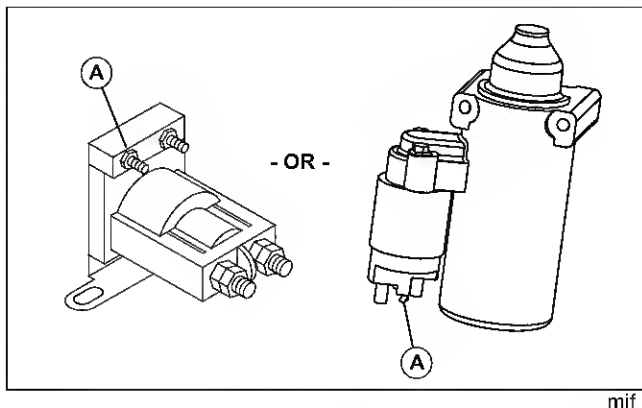
- c. Install jumper wire between terminals B (704 Pur wire) and D (702 Pur wire).

### Test Procedure A:

#### Test Conditions:

- Park machine safely.
- Key switch in START position.
- PTO/RIP switch OFF.
- Park brake ON.

### Cranking Power



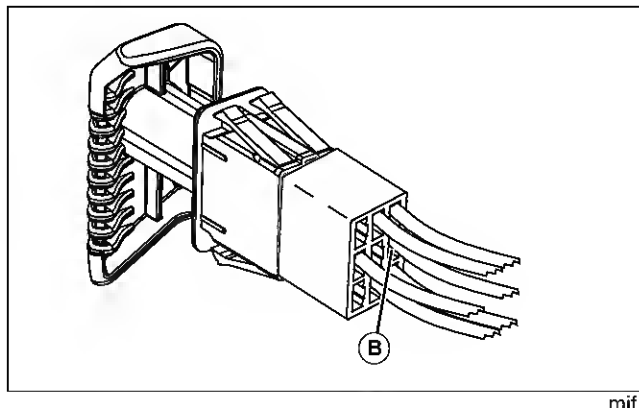
1. Close hood switch or install jumper in hood switch connector. Is battery voltage present at the starting

motor solenoid, Pur wire (A)?

Yes: Cranking circuit is operational. Test the starting solenoid and the starting motor. See "Starting Solenoid Test" on page 349.

Yes: Test hood switch. See "Hood Switch Test" on page 356. If hood switch is good, check for switch position and that it closes when the hood is closed.

No: Go to next step.



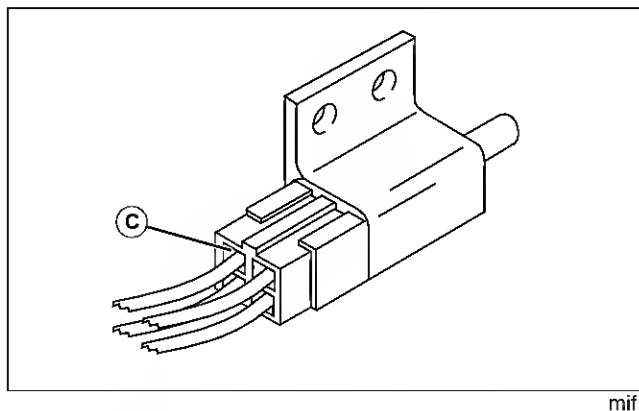
2. Is battery voltage present at the PTO/RIP switch, 703 Pur wire (terminal 2) (B)?

Yes: Go to next step.

No: Check 703 Pur wire and connections.

No: Test S4 key switch. See "Key Switch Test (SN 040001-)" on page 359.

No: Test unswitched power circuit. See "Power Circuit Diagnostics" on page 319

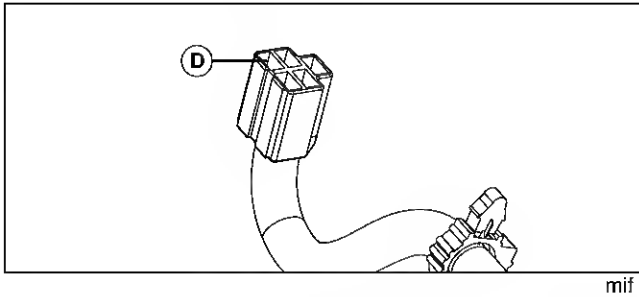


3. Is battery voltage present at the brake switch, 701B Pur wire (C)?

Yes: Go to next step.

No: Check 701B and -A Pur wires, connector X6.

No: Test PTO/RIP switch. See "PTO/RIP Switch Test" on page 353.

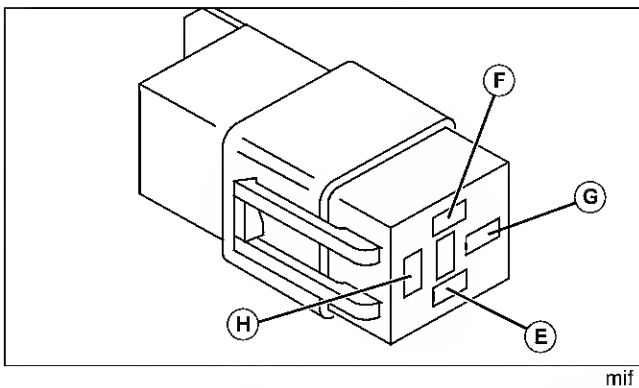


4. Is battery voltage present at hood switch connector, 702 Pur wire (D)?

Yes: Go to next step.

No: Check 702 Pur wire and connections.

No: Test brake switch. See "Brake Switch Test" on page 356.



5. Is battery voltage present at K1 start relay, 704 Pur wire (terminal 86) (E)?

Yes: Go to next step.

No: Test hood switch. See "Hood Switch Test" on page 356. Check switch position and that it closes when the hood is closed. Check 704 Pur wire.

6. Is there continuity between K1 start relay 100G Blk wire (terminal 85) (F) and ground?

Yes: Go to next step.

No: Check 100G, -C and -B Blk wires to W1 ground.

7. Is battery voltage present at K1 start relay, 204 Red wire (terminal 30) (G)?

Yes: Go to next step.

No: Check F3 fuse and 204 Red wire.

8. Is battery voltage present at K1 start relay, 700A Pur wire (terminal 87) (H)?

Yes: Check 700A Pur wire and connections. Check connector X2 and Pur wire to starter solenoid.

No: Test start relay. See "Relay Test (SN 040001-)" on page 352.

# ELECTRICAL THEORY OF OPERATION EXPORT (SN 150001-)

### Charging Circuit Operation

**Function:**

To maintain battery voltage at 12.6 volts or higher.

**Operating Conditions:**

The engine must be running for the charging system to operate.

- Key switch On, engine running
- Operator on seat

or,

- Key switch On, engine running
- Brake locked
- Operator off seat

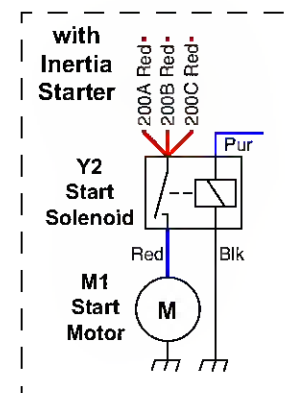
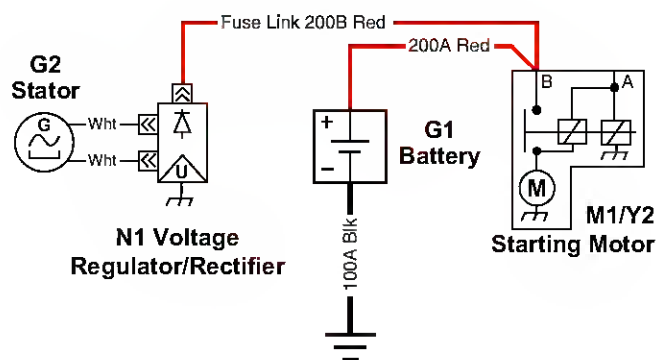
### Charging Circuit Wiring Schematic

**Theory of Operation:**

The charging system is a permanent magnet and stator design.

A permanent magnet is located in the flywheel. As the flywheel turns, the magnet moves across the G2 stator, inducing an AC current in the stator windings. The AC current is converted by the N1 regulator/rectifier into the DC current needed to charge the battery. The regulator adjusts the charging current in order to maintain the system voltage at approximately 14.7 volts.

Fuse link 200B protects the charging system from excessive currents. The regulator/rectifier is connected to frame ground via a black jumper wire.



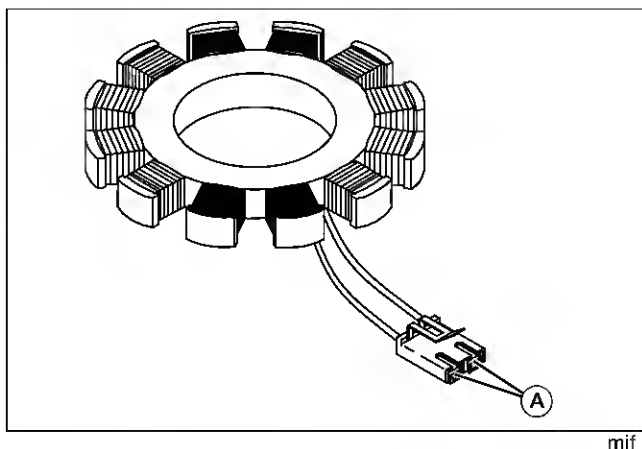
## Charging Circuit Diagnostics

### Test Procedure A:

#### Test Conditions:

- Machine parked safely.
- Park brake locked.
- PTO in off position.
- Battery fully charged.
- Stator connector unplugged.
- Voltmeter set to AC.
- Engine running at full throttle.

### Charging System - Stator



1. Is the voltage measured between stator lead(s) approximately 28 volts AC or higher (A)?

Yes: Go to next procedure.

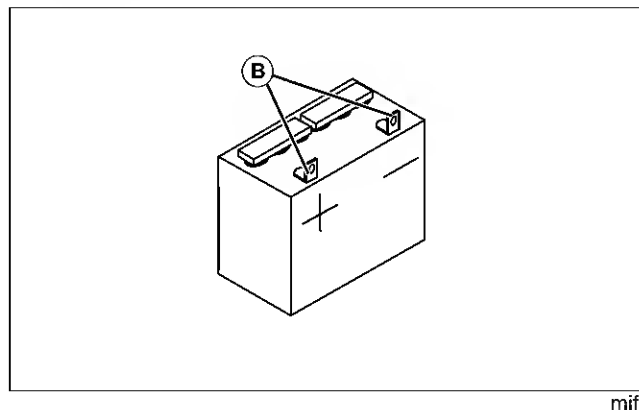
No: If below 28 volts AC, replace stator.

### Test Procedure B

#### Test Conditions:

- Machine parked safely.
- Park brake locked.
- PTO in off position.
- Battery fully charged.
- Stator connected.
- All electrical loads off (headlights, accessories).
- Engine running at low idle, then high idle during test.

### Charging System



1. Is the voltage across the battery terminals rise from approximately 12.5 VDC to 13.5 VDC or higher when the throttle is moved from low idle to high idle.

Yes: Test complete.

No: Check for poor connections between battery, starting motor solenoid, and voltage regulator/rectifier. Check regulator ground wire.

No: Test voltage regulator/rectifier. See "Regulated Voltage Test" on page 345 and other related tests.

## Ignition Circuit Operation

### Function:

To control the ignition coils ability to create a spark.

### Operating Conditions, Stopping Engine:

- Key switch in Off position

- or -

- Operator off seat
- Park braked unlocked

- or -

- Hood open

### Theory of Operation, Stopping Engine:

The engine is shut off by grounding the T1 and T2 ignition coils. With the ignition primary coils grounded, a spark cannot be produced.

Operating current for the interlock module, seat switch and brake switch is supplied by the switched power circuit. See "Power Circuit Operation" on page 316. When the key switch is in the Off position, a module-created ground path shunts the 900-series Wht wires of the ignition coils and P1 hour meter.

If the interlock module senses that the logic inputs from both the seat switch (810B Pnk wire) and brake switch (705B Brn wire) are removed, the 900-series Wht wires are again grounded.

The hood switch has priority over the interlock module in the control of the ignition coils. Whenever the hood is open, the hood switch simultaneously grounds the 900-series Wht wires and disables the cranking circuit.

The seat switch and brake switch also provide the logic inputs to the interlock module for the fuel shutoff solenoid circuit. If both the seat switch and brake switch are in the off position, the fuel shutoff solenoid is de-energized, stopping the flow of fuel within the carburetor.

### Operating Conditions, Running Engine:

- Hood closed
- Key switch in On or Start position
- Operator on seat
- or -
- Hood closed
- Key switch in On or Start position
- Operator off seat
- Park braked locked.

### Theory of Operation, Running Engine:

The ignition system is a transistor-controlled magneto design. Ignition timing is controlled by the transistor and is not adjustable. As the engine turns, a flywheel magnet induces a current pulse into the magneto ignition coil. The ignition coil steps up the pulse to produce a high voltage arc across the spark plug gap. This spark ignites the fuel/air mixture in the engine cylinder.

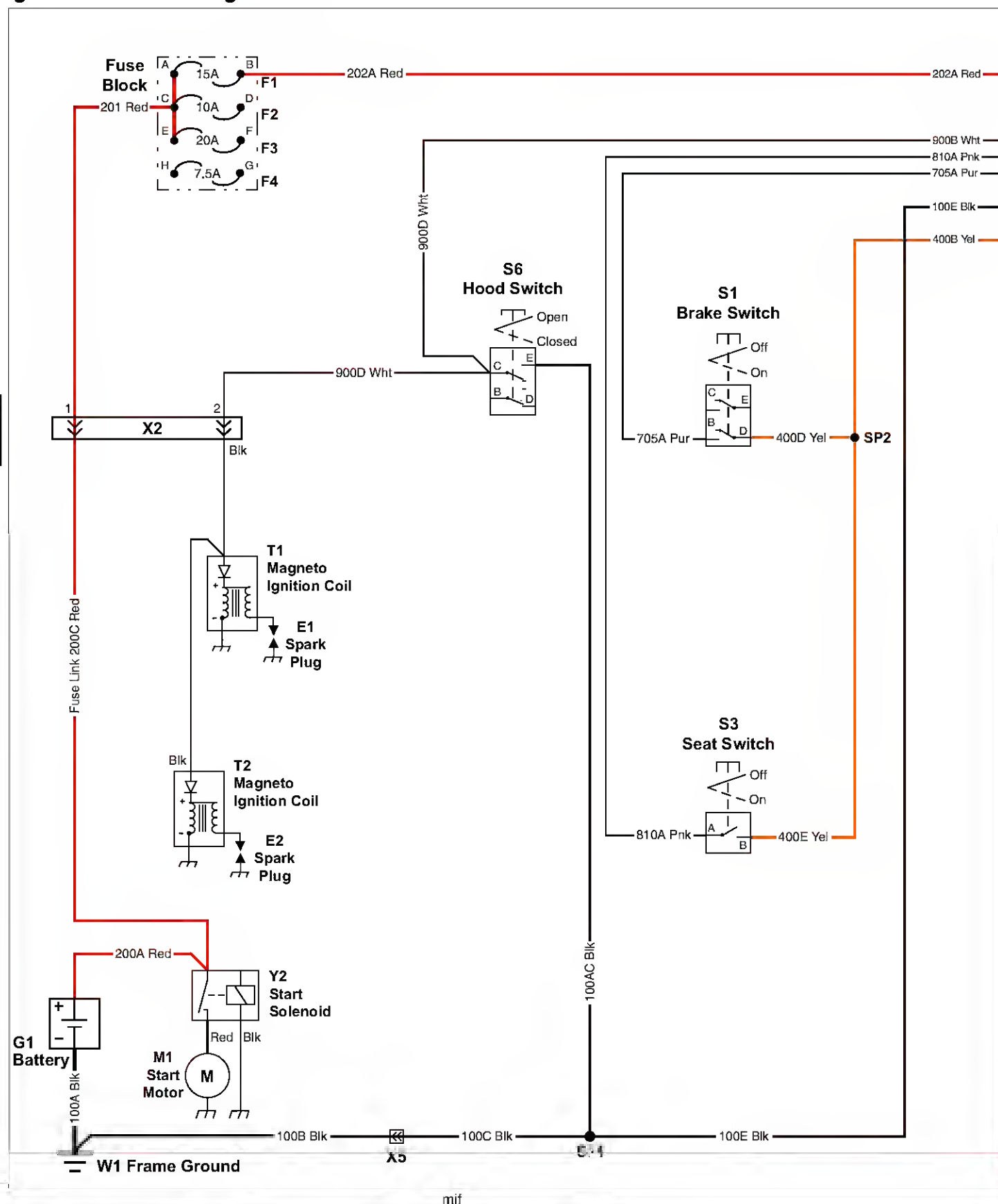
Operating current for the interlock module, seat switch and brake switch is supplied by the switched power circuit. With the key switch in the On position, hood closed, and the seat and/or brake switch activated, the interlock module and hood switch will open the ground shunt paths to the ignition primary coils. A high-voltage spark can now be generated.

Additionally, the interlock module energizes the fuel shutoff solenoid, allowing fuel to flow within the carburetor. See "Fuel Shutoff Solenoid Circuit Operation" on page 291.

The interlock module is a solid-state device with no field-serviceable components.

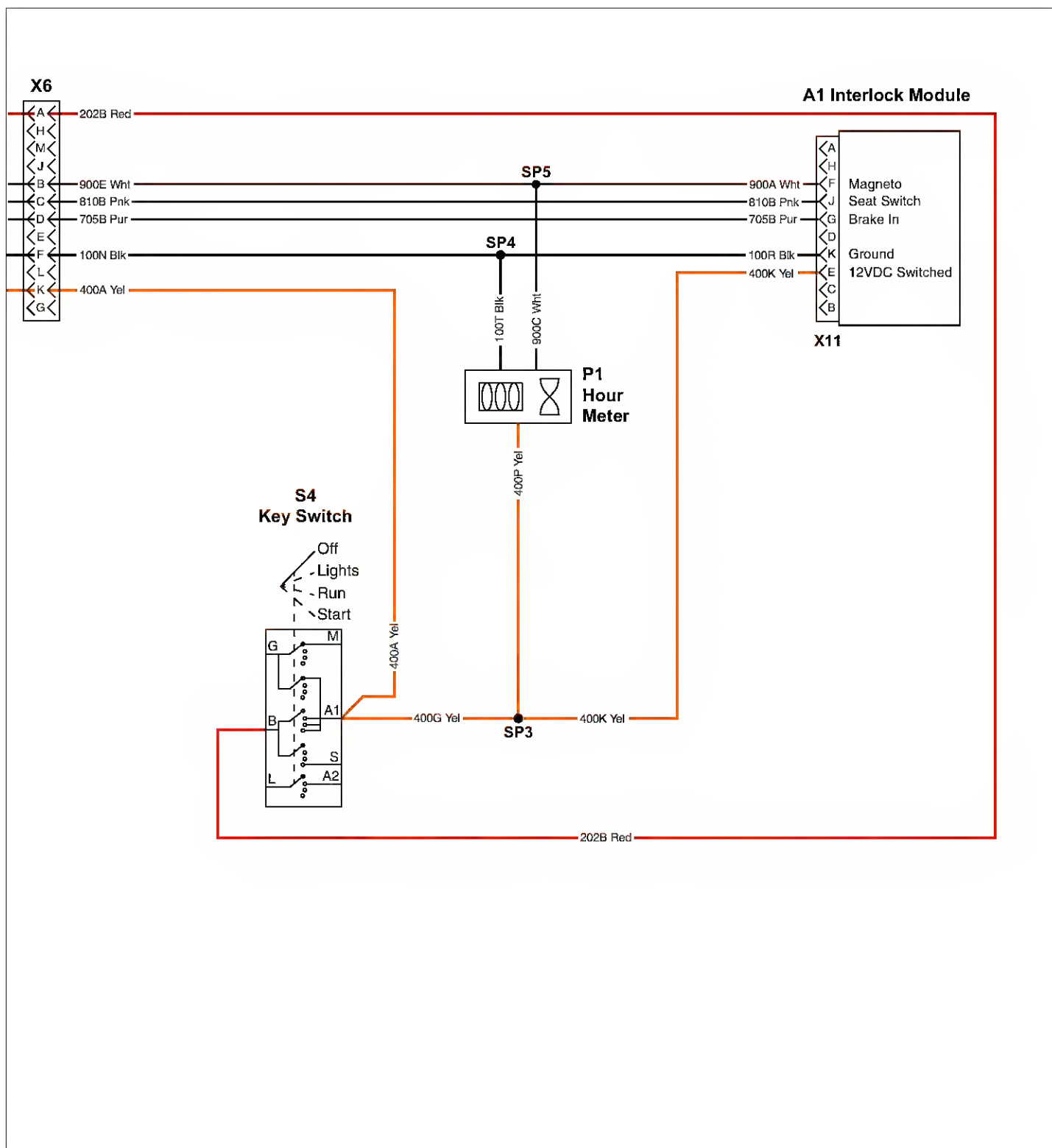
# ELECTRICAL THEORY OF OPERATION EXPORT (SN 150001-)

## Ignition Circuit Wiring Schematic





# ELECTRICAL THEORY OF OPERATION EXPORT (SN 150001-)



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# ELECTRICAL THEORY OF OPERATION EXPORT (SN 150001-)

## Ignition Circuit Diagnostics

### Hood Switch

During normal operation the hood switch must be closed. The circuit can be tested if the hood is removed and the hood switch is manually closed (see "Hood Switch Test" on page 356). Leave the hood switch connected to the harness unless directed otherwise.

#### Test Procedure A:



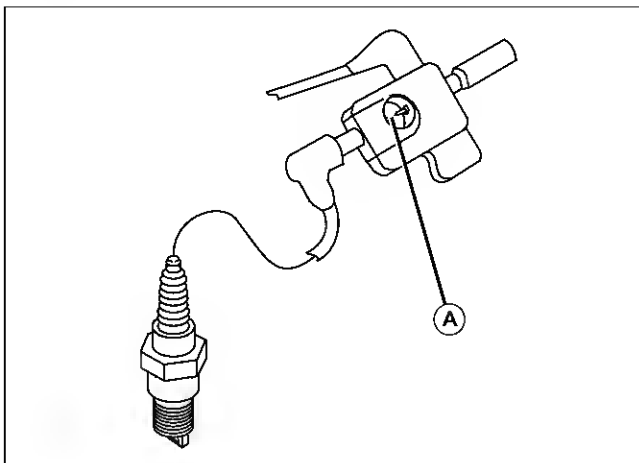
**Caution: Avoid Injury! Stay clear of moving parts. Engine will turn over and may start during this test.**

#### Test Conditions:

- Power circuits checked and OK. See "Power Circuit Diagnostics" on page 278.
- Machine parked safely with park brake locked.
- Ignition spark tester installed between spark plug and spark plug lead.
- PTO/RIP switch Off.
- Fuel shutoff solenoid disconnected to prevent starting.
- Hood switch held closed.
- Key switch in Start position, engine cranking during test.

**Note: Before replacing ignition components, first verify that the flywheel key is not sheared or distorted.**

#### Spark Test:



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1. Does the spark tester (A) indicate a hot, blue spark?

Yes: Check spark plug gap and condition of spark plug. If plug is good, continue testing ground circuit.

No: Test for open spark plug lead. Test ignition coil(s).

Check armature air gap. See ignition coil adjustment in respective engine section. Test flywheel magnets. See "Flywheel Ignition Magnet Test" on page 348. If ok, go to next procedure.

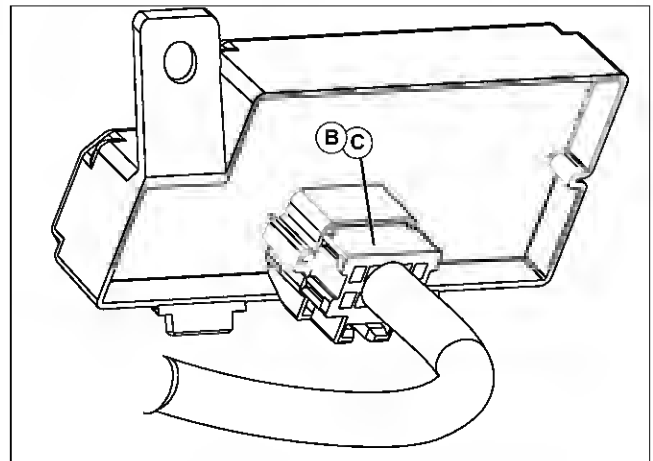
Repeat procedure for opposite spark plug.

#### Test Procedure B:

##### Test Conditions:

- Machine parked safely with park brake locked.
- Key switch in Off position.
- Hood switch held closed.

#### Ignition Off:



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1. Unplug connector X11 from interlock module. Set meter to diode test. At the connector, measure between the 900A Wht wire (B) and ground. Reverse test leads and repeat measurement. Does meter read approximately .6 ~ .7 volts (one diode drop) in one direction?

Yes: Go to next step.

No: Check the 900-series Wht wires and connections.

No: Disconnect hood switch from harness. If readings change, test hood switch. See "Hood Switch Test" on page 356.

2. Is there continuity between the interlock module connector X11, 100R Blk wire (C) and ground?

Yes: Ensure that safety interlock (seat and brake switch) circuits are functioning properly.

Yes: Replace the A1 interlock module.

No: Check the 100R, -N, -E, -C and -B Blk wires and connections.

## Fuel Shutoff Solenoid Circuit Operation

### Function:

To energized the fuel shutoff solenoid when the proper operating condition are met.

### Operating Conditions:

- Key switch in START or ON
- and,
- Operator ON the seat
- or,
- Brake pedal depressed

### Theory of Operation:

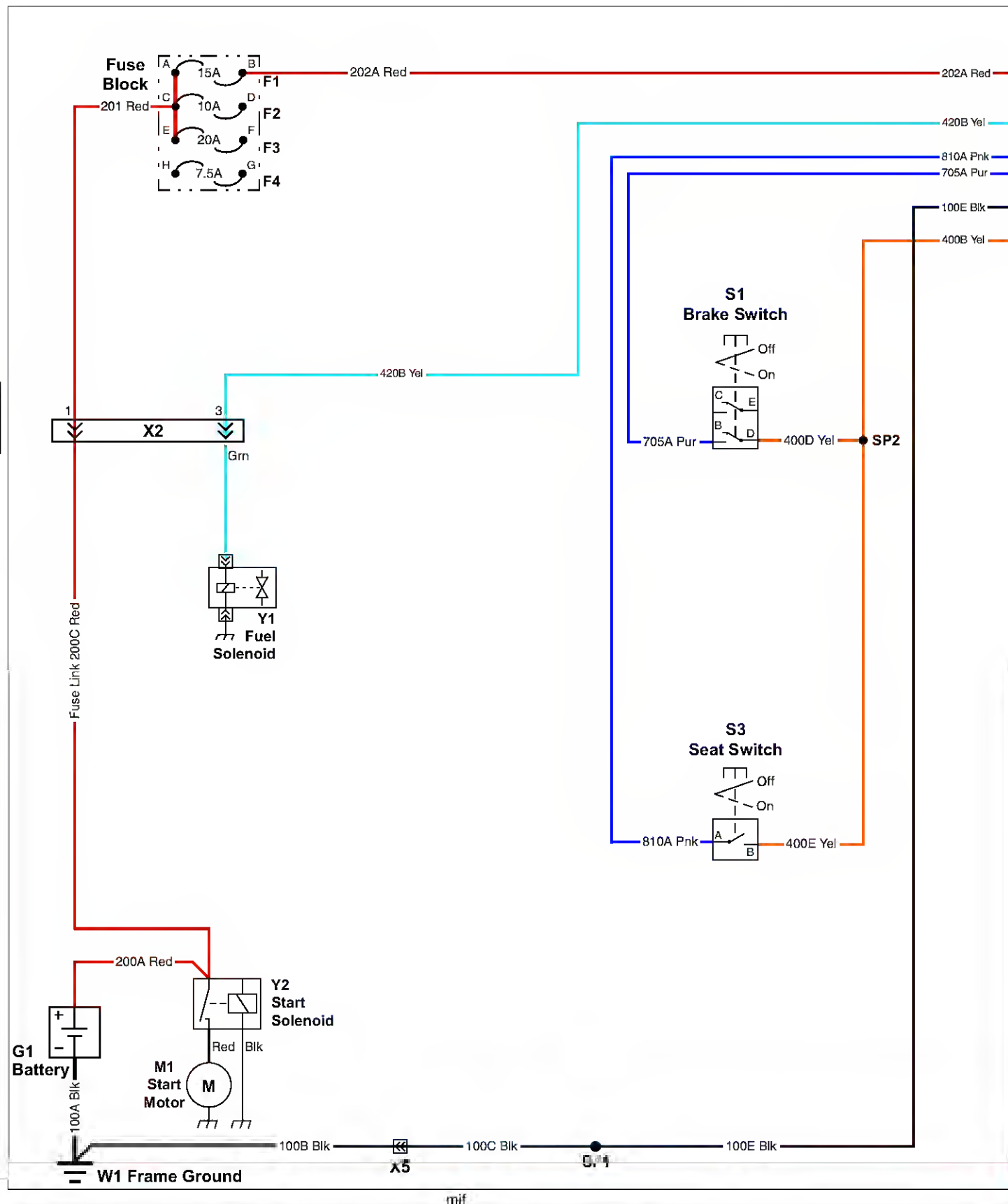
The Y1 fuel shutoff solenoid uses an electromagnetic coil to operate a plunger. When the solenoid is energized, the plunger retracts, allowing fuel to flow within the carburetor. Power for the fuel shutoff solenoid is supplied and controlled by the interlock module. To prevent engine backfire at shutdown, the module is designed to turn off the solenoid just before the ignition spark is stopped.

When the key switch is in the On or Start position, the switched power circuit provides current for the interlock module, seat switch and brake switch. See "Power Circuit Operation" on page 316.

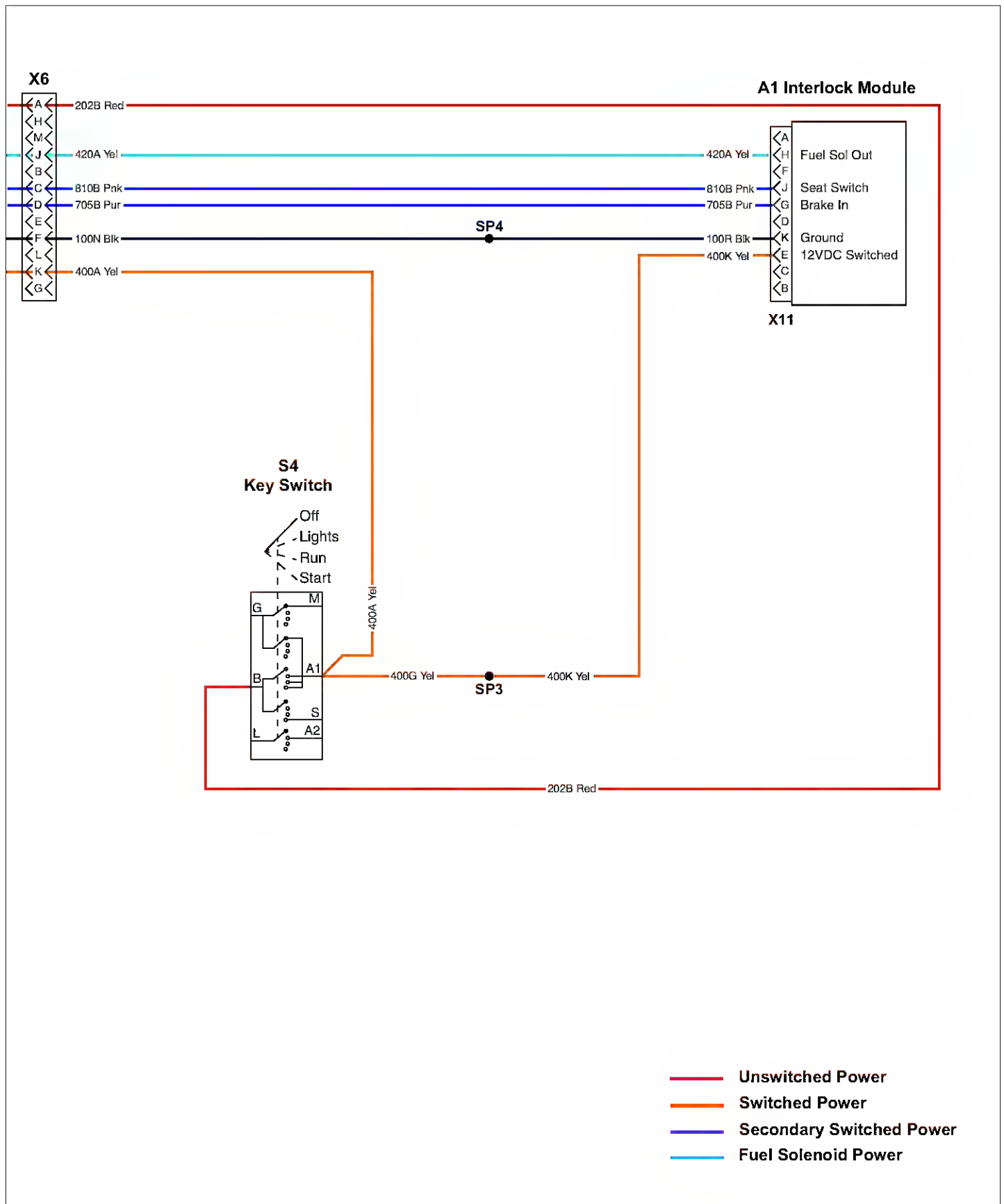
In order for the fuel shutoff solenoid to be activated, the interlock module requires a "switch closed" input signal from either the seat switch (810A and -B Pnk wires) or brake switch (705A and -B Pur wires). If neither signal is present, the module's output to the solenoid (420A and -B Yel wires) is turned off.

# ELECTRICAL THEORY OF OPERATION EXPORT (SN 150001-)

## Fuel Shutoff Solenoid Circuit Wiring Schematic



## ELECTRICAL THEORY OF OPERATION EXPORT (SN 150001-)



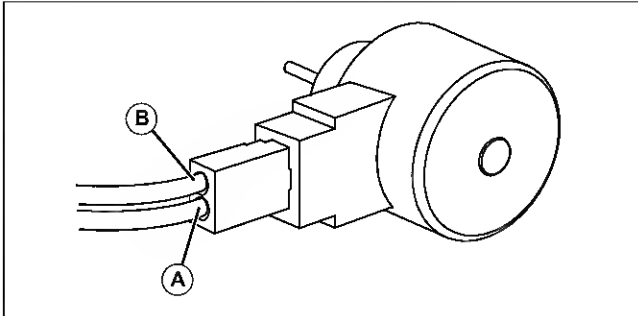
## Fuel Shutoff Solenoid Circuit Diagnostics

### Test Procedure A:

#### Test Conditions:

- Brake locked.
- PTO OFF.
- Key switch On, engine not running.
- Operator off seat.
- Transmission in neutral.

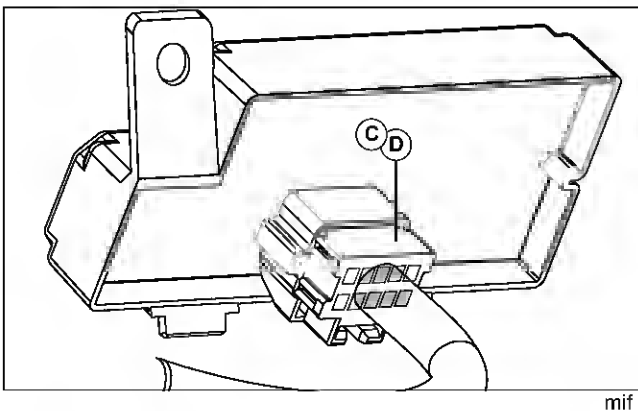
### Fuel Shutoff Solenoid - Brake Circuit:



1. Is battery voltage present at the fuel shutoff solenoid Grn wire (A)?

Yes: Fuel shutoff circuit is functioning properly. Test the fuel shutoff solenoid. See "Fuel Shutoff Solenoid Test" on page 352. Check Blk wire (B) connection to ground.

No: Go to next step.

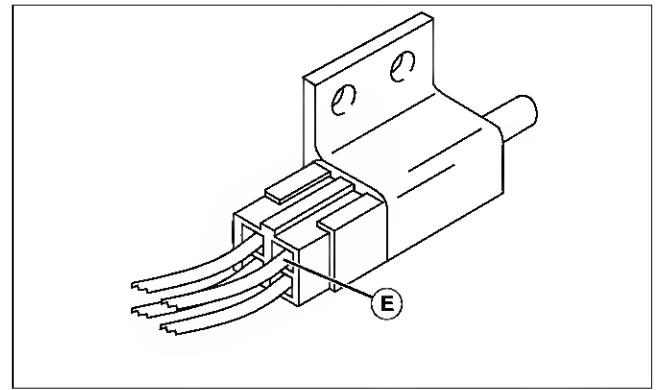


2. Is battery voltage present at interlock module connector X11, wires 400K Yel and 705B Pur (C) (D)?

Yes: Check the 420A and -B Yel wires and Grn wire and connections. Check the 100R Blk wire at module for continuity to ground. If ok, replace interlock module.

No: 400K Yel wire: See "Power Circuit Diagnostics" on page 319.

No: 705B Pur wire: go to next step.



3. Is battery voltage present at the brake switch, 705A Pur wire (E)?

Yes: Check the 705A and -B Pur wires and connections. If ok, replace the A1 interlock module.

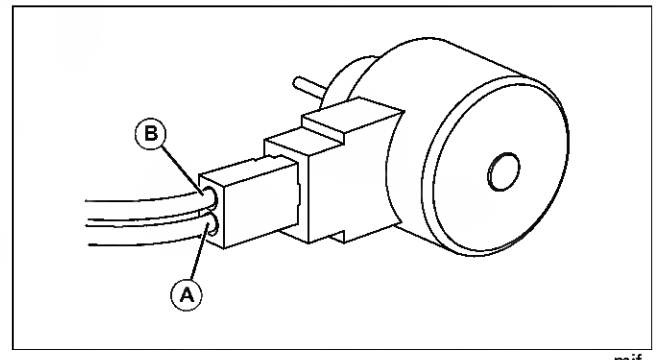
No: Test Brake switch. See "Brake Switch Test" on page 356. Recheck switched power circuit. See "Power Circuit Diagnostics" on page 319.

### Test Procedure B:

#### Test Conditions:

- PTO OFF.
- Key switch On, engine not running.
- Operator on seat.
- Transmission in neutral.
- Machine on level surface, Brake off.

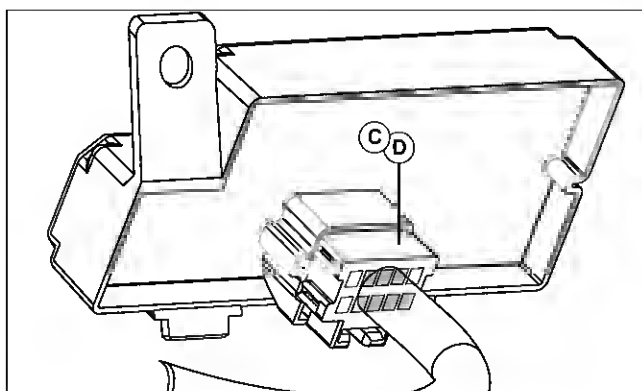
### Fuel Shutoff Solenoid - Seat Circuit:



1. Is battery voltage present at the fuel shutoff solenoid Grn wire (A)?

Yes: Fuel shutoff circuit is functioning properly. Test the fuel shutoff solenoid. See "Fuel Shutoff Solenoid Test" on page 352. Check Blk wire (B) connection to ground.

No: Go to next step.

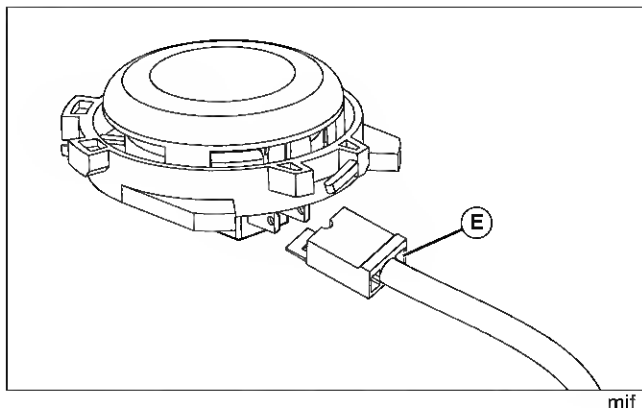


2. Is battery voltage present at interlock module connector X11, wires 400K Yel and 810B Pnk (C) (D)?

Yes: Check the 420A and -B Yel wires and Grn wire and connections. Check the 100R Blk wire at module for continuity to ground. If ok, replace interlock module.

No: 400K Yel wire: See "Power Circuit Diagnostics" on page 319.

No: 810B Pnk wire: go to next step.



3. Is battery voltage present at the seat switch, 810A Pnk wire (E), with switch depressed?

Yes: Check the 810A and -B Pnk wires and connections. If OK, replace the interlock module.

No: Test S3 seat switch. See "Seat Switch Test (SN 040001-)" on page 358. Recheck switched power circuit. See "Power Circuit Diagnostics" on page 319.

## PTO/RIP Circuit Operation

### PTO Clutch Operating Conditions:

- Key switch On
- Operator on seat
- PTO/RIP switch On
- Brake released
- Transmission in forward or neutral

or;

- Key switch ON
- Operator on seat
- Brake released
- PTO/RIP switch in Momentary ON position while transmission shifted to reverse, then PTO/RIP switch in On position while transmission in reverse.

### Theory of Operation:

The PTO is electro/mechanical device (electric clutch) powered and controlled by the A1 interlock module.

The engine crankshaft drives the PTO clutch. When operating conditions are met, the interlock module output (Pin A) sources 12 VDC to energize the PTO electric clutch. The clutch sheave is then engaged with the engine crankshaft. The interlock module will disengage the PTO clutch should any operating condition not be met.

### The interlock module performs the following functions:

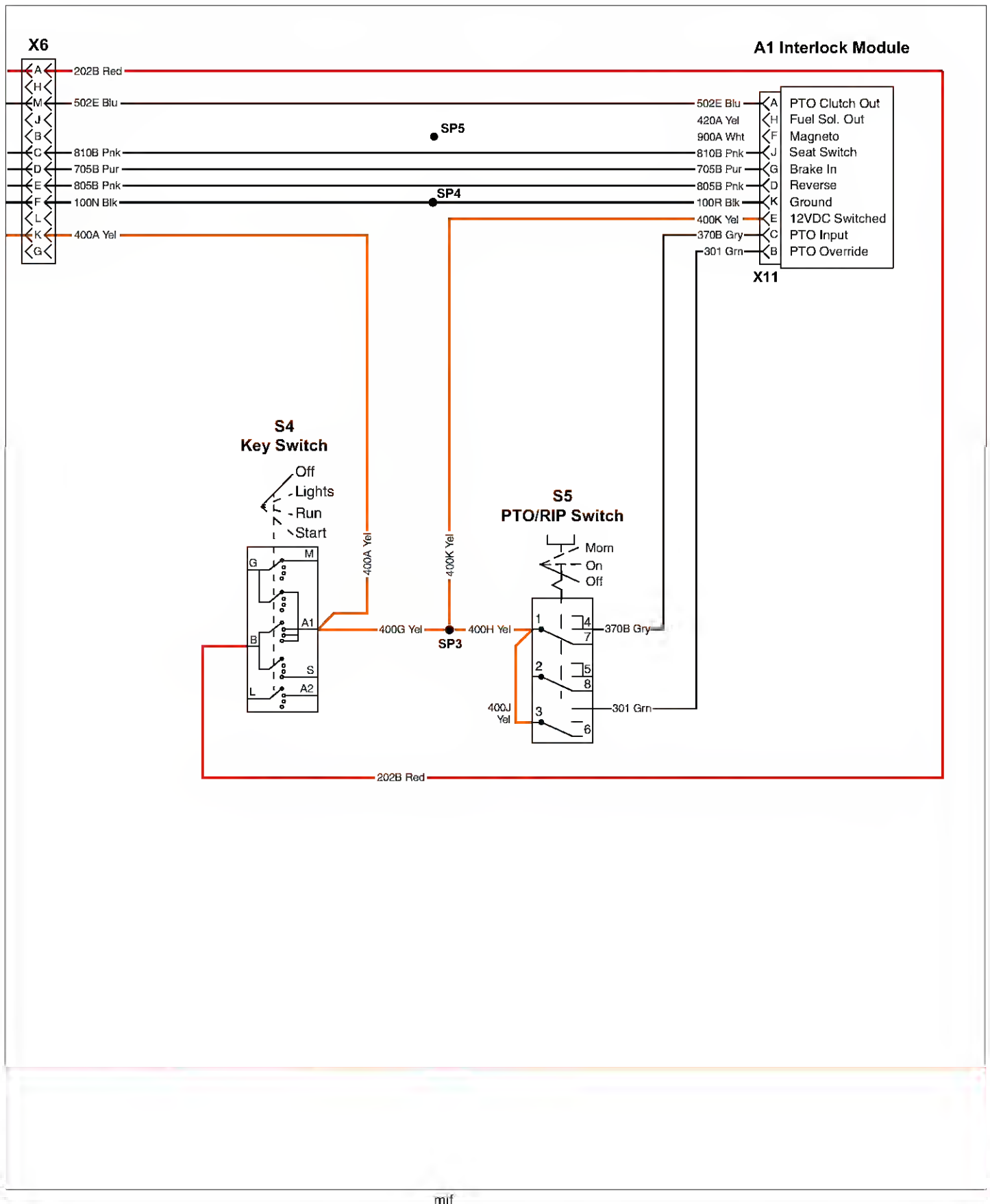
- Turn on the electric clutch if the operator is in the seat, the PTO/RIP switch is in the ON position, and the transmission is in forward or neutral.
- Maintain power to the electric clutch if the operator is in the seat, and chooses to mow in reverse. By lifting the PTO/RIP switch to the Momentary ON position while shifting into reverse, the reverse override function is enabled, latching the power to the clutch.
  - Disables the reverse override when the operator shifts the transmission from reverse to forward or neutral.
- Turn off and latch off the electric clutch if the PTO is on and the operator shifts into reverse without lifting the PTO/RIP switch. To reset the latch, the operator must place the PTO/RIP switch in the OFF position.
- Turn off and latch off the electric clutch if the operator gets off the seat. A short time delay protects against bouncing. To reset the latch, the operator must place the PTO/RIP switch in the OFF position.
- Turn off and latch off the electric clutch if the operator enables the brake switch.

### PTO/RIP Circuit Wiring Schematic





# ELECTRICAL THEORY OF OPERATION EXPORT (SN 150001-)



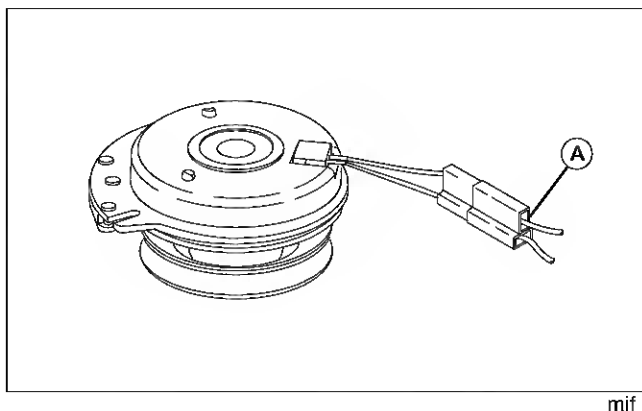
## PTO/RIP Circuit Diagnostics

### Test Procedure A:

#### Test Conditions:

- Power circuits checked and OK. See "Power Circuit Diagnostics" on page 278.
- Brake unlocked.
- Transmission in neutral.
- Operator on seat.
- Key switch On, engine not running.
- PTO/RIP switch On, reset as required.

#### PTO On:



1. Is battery voltage present at the PTO clutch connector X7, 501A Blu wire (A)?

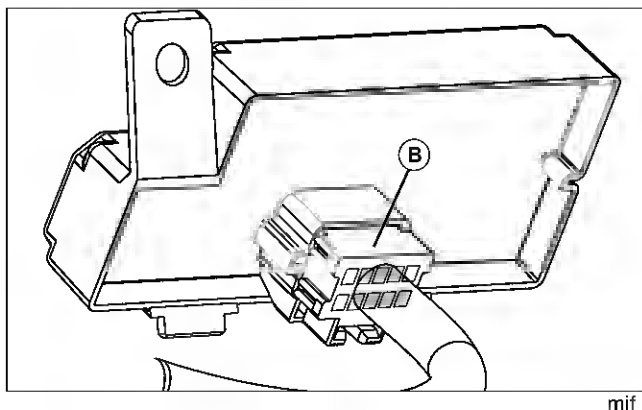
Yes: PTO clutch circuit is functional. Test the PTO clutch. See "PTO Clutch Test" on page 353.

Yes: Check for continuity to ground on 100D Blk wire.

No: Ensure that safety interlock (seat, brake and reverse switch) circuits are functioning properly.

No: Test F4 fuse. Check 501A, 502C and -E Blu wires.

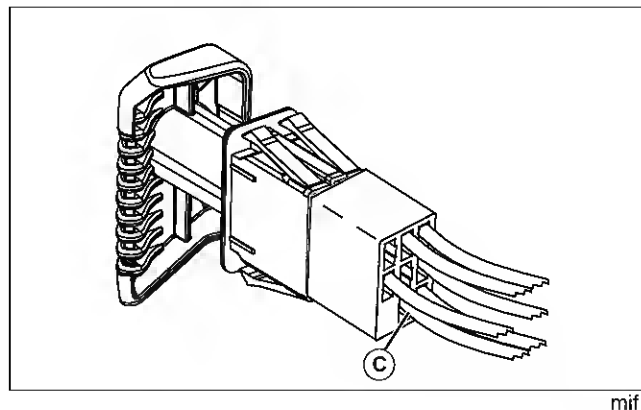
No: Test V1 Diode. See "Diode Test" on page 355.



2. Is battery voltage present at the interlock module connector 370B Gry wire (B)?

Yes: Recheck all power, ground and safety interlock circuits. If OK, replace A1 interlock module.

No: Check the 370B Gry wire and connections. Test PTO/RIP switch. See "PTO/RIP Switch Test" on page 353.



3. When PTO switch is pulled up to the RIP position, does battery voltage appear at the 301 Grn wire (C)? Return PTO switch to ON position.

Yes: Check the 301 Grn wire and connections. Go to next procedure.

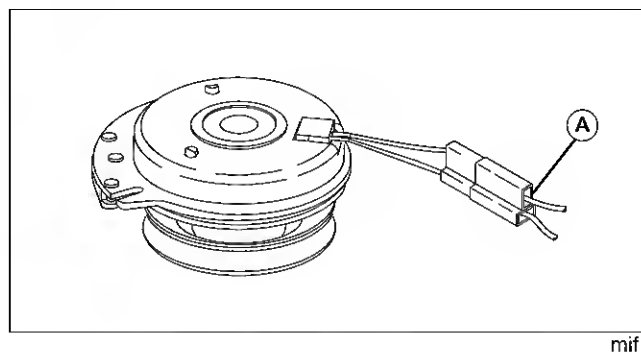
No: Test PTO/RIP switch. See "PTO/RIP Switch Test" on page 353.

### Test Procedure B:

#### Test Conditions:

- Brake unlocked.
- Reverse pedal depressed (transmission moved to reverse) for each test.
- Operator on seat.
- Key switch On, engine not running.
- PTO/RIP switch On, reset as required.

#### Reverse Shutoff Circuit:

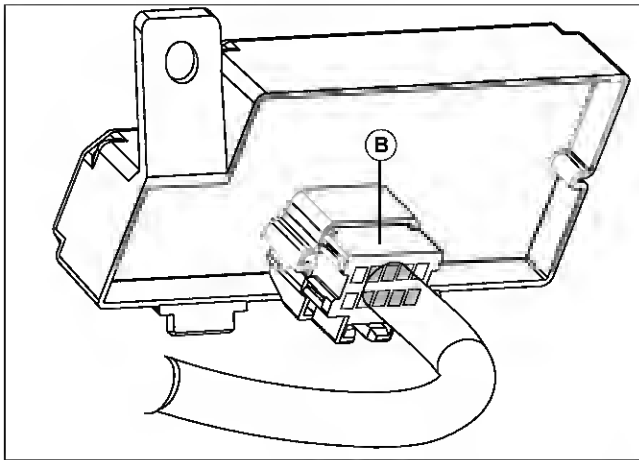


# ELECTRICAL THEORY OF OPERATION EXPORT (SN 150001-)

1. Does voltage at the PTO clutch connector X7, 501A Blu wire (A) drop to less than 0.5 volts when the reverse pedal is depressed?

Yes: PTO clutch reverse shutoff circuit is functional.

No: Go to next step.

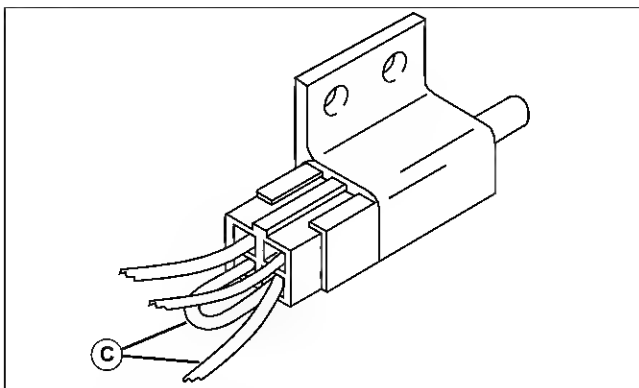


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2. Does voltage at the interlock module connector 805B Pnk wire (B) drop to less than 0.5 volts when the reverse pedal is depressed?

Yes: Check the 501/502-series Blu wires and connections for a short to a battery voltage. If ok, replace the interlock module.

No: Go to next step.



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3. Is battery voltage present at the reverse switch 400S and -F Yel wires (C)?

Yes: Check the 805A and -B Pnk wires and connections. If OK, test the reverse switch. See "Reverse Switch Test and Adjustment" on page 357.

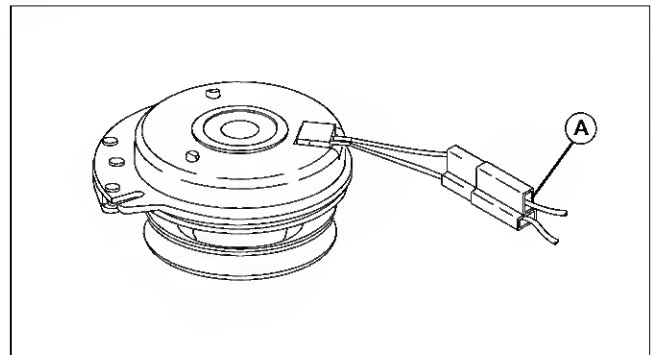
No: Check switched power circuit. See "Power Circuit Diagnostics" on page 319.

## Test Procedure C:

### Test Conditions:

- Brake unlocked.
- Operator on seat.
- Key switch On, engine not running.
- PTO/RIP switch pulled up from On position to momentary position,
- then -
- Reverse pedal depressed (transmission moved to reverse) for each test.

### Momentary Circuit:



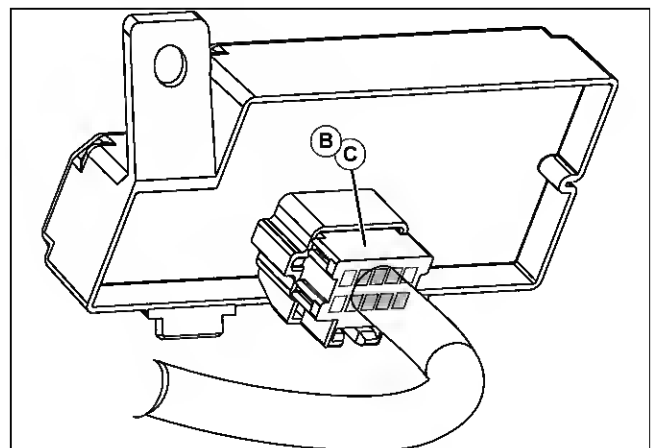
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1. Does the battery voltage remain present at the PTO clutch connector X7, 501A Blu wire (A) when the S5 PTO/RIP switch is pulled up to the momentary position and then the reverse pedal is depressed?

Yes: PTO clutch momentary circuit is functional. Ensure that there is continuity to ground over 100D Blk wire.

No: Verify that the PTO/RIP switch is pulled-up and held before and until the reverse pedal is depressed. Go to next step.

No: Recheck Reverse Shutoff circuit.



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2. Is battery voltage present at the interlock module connector 370B Gry wire (B) and 301 Grn wire (C) when the PTO/RIP switch is pulled up to the momentary position?

Yes: Replace A1 interlock module.

No: Check power circuit. See "Power Circuit Diagnostics" on page 278.

No: Check the 370B Gry wire and connections. If OK, test the PTO/RIP switch. See "PTO/RIP Switch Test" on page 353.

No: Check the 301 Grn wires and connections. If OK, test the PTO/RIP switch. See "PTO/RIP Switch Test" on page 353.

## Headlight Circuit Operation

### Function:

To provide power to the headlights for illumination if desired by the operator.

### Operating Conditions

- Key switch in ON With Lights position

### Theory of Operation:

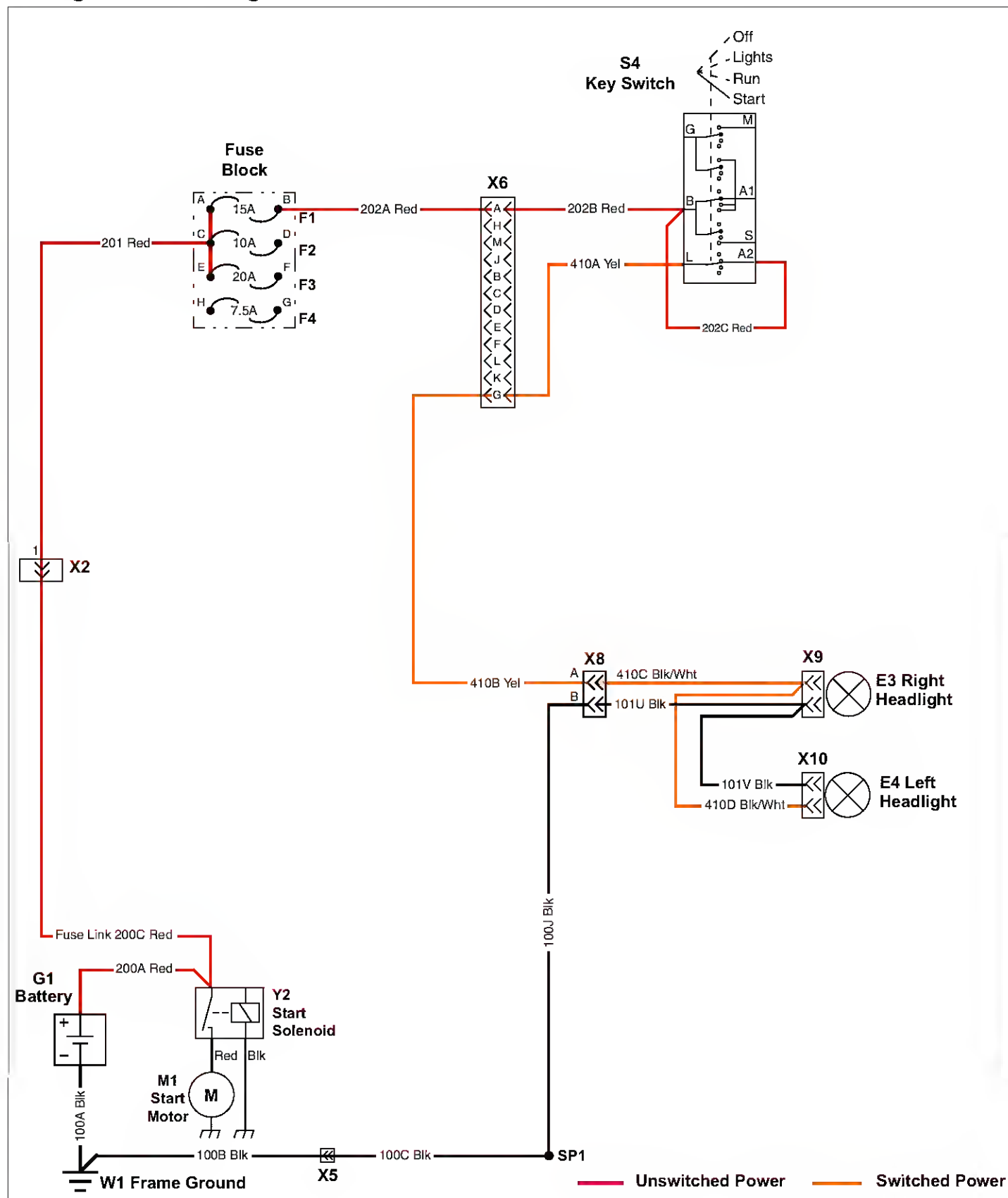
The unswitched power circuit provides power to the S4 key switch. See "Power Circuit Operation" on page 275.

With the key switch in the ON With Lights position, current flows from switch terminal A2 to terminal L, and then via the 410A and -B Yel wires to the headlight wiring harness connector X8.

The ground circuit for the headlights is provided by the 100U Blk (RH headlight), 100V Blk (LH headlight), 100J, -C and -B Blk wires to the W1 frame ground.

# ELECTRICAL THEORY OF OPERATION EXPORT (SN 150001-)

## Headlight Circuit Wiring Schematic



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## Headlight Circuit Diagnostics

040001-)" on page 359.

### Test Procedure:

No: Check the power circuit. See "Power Circuit Diagnostics" on page 319.

### Test Conditions:

- Key switch turned to On With Lights position, engine not running.

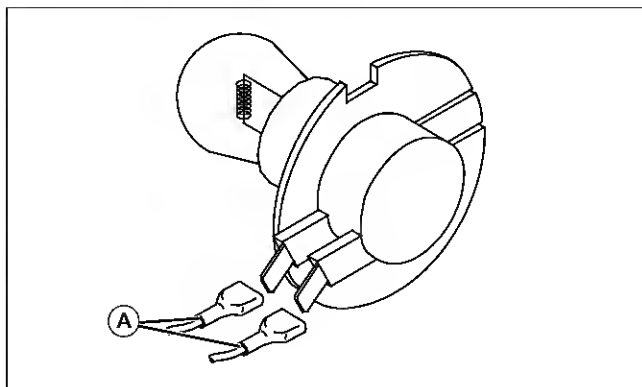
### Headlights:

1. Are both headlights illuminated?

Yes: Circuit is functioning properly.

No: Test the bulb of the light(s) that are not illuminated.

Go to next step.



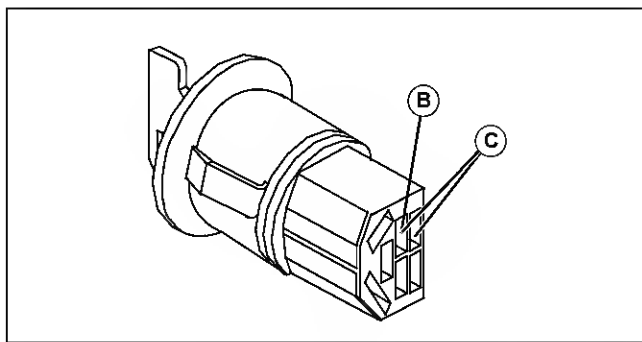
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2. Disconnect the harness from the headlights. Is battery voltage present across the wiring harness connector terminals (A) for each headlight?

Yes: Replace the bulb(s) not illuminated.

No: Check 410C and -D Blk/Wht wires.

No: Ensure that there is continuity to ground over 100U, -V and -J Blk wires.



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3. Is battery voltage present at key switch terminal L, 410A Yel wire (B)?

Yes: Check X6 connector and 410A and -B Yel wires.

No: Check for power at key switch 202C Red jumper wire (C). Test key switch. See "Key Switch Test (SN

# ELECTRICAL TESTS AND ADJUSTMENTS

## Tests and Adjustments

### Ground Circuit Tests

#### Reason:

To check for open circuits, loose terminal wire crimps, poor connections, or corrosion in the ground circuit.

#### Equipment:

- Ohmmeter or Voltmeter

**Note:** *The voltmeter method checks ground connections under load.*

#### Procedure - Ohmmeter Method:

1. Park machine Safely with park brake locked. See "Park Machine Safely" in the Safety section.
2. Raise hood.
3. Connect ohmmeter negative (black) lead to negative terminal of battery. Connect ohmmeter positive (red) lead to negative terminal of battery and record reading.
4. Connect ohmmeter red lead to ground terminal of circuit or component to be tested that is closest to the battery negative terminal. Resistance reading must be the same or very close to the battery negative terminal reading. Work backward from the battery on the ground side of the problem circuit until the resistance reading increases above 0.1 ohms. If the reading is above 0.1 ohms, the problem is between the last two test points. If a problem is indicated, disconnect the wiring harness connector to isolate the wire or component and check resistance again. Maximum allowable resistance in the circuit is 0.1 ohms. Check both sides of the connectors closely, as disconnecting and connection may temporarily solve problem.

#### Procedure - Voltmeter Method:

1. Move Forward/Reverse pedals to NEUTRAL position.
2. Raise hood.
3. Connect voltmeter negative (black) lead to negative terminal of battery.
4. Connect voltmeter positive (red) lead to ground terminal (A) of circuit or component to be tested. Be sure that the component circuit is activated (key ON, switch(es) CLOSED) so that voltage will be present at the component. Record voltage. Voltage must be greater than 0, but less than 1 volt. Some components will have a very small voltage reading on the ground side and still be operating correctly.

#### Results:

- If voltage is 0, the component is open.
- If voltage is greater than 1 volt, the ground circuit is bad.

Check for open wiring, loose terminal wire crimps, poor connections, or corrosion in the ground circuit.

### Battery Test



**Caution: Avoid Injury! Sulfuric acid in battery electrolyte is poisonous. It is strong enough to burn skin, eat holes in clothing, and cause blindness if splashed into the eyes.**

**Avoid hazard by:**

- Filling batteries in well ventilated area.
- Wearing eye protection and rubber gloves and vest.
- Avoiding breathing fumes when electrolyte is added.
- Avoid spilling or dripping electrolyte.
- Use proper jump-start procedure.

**If you spill acid on yourself:**

- Flush your skin with water.
- Apply baking soda or lime to help neutralize the acid.
- Flush your eyes with water for 10 - 15 minutes. Get medical attention immediately.

**If acid is swallowed:**

- Drink large amounts of water or milk.
- Then drink milk of magnesia, beaten eggs, or vegetable oil.
- Get medical attention immediately.

#### Reason:

To check condition of battery and determine battery voltage.

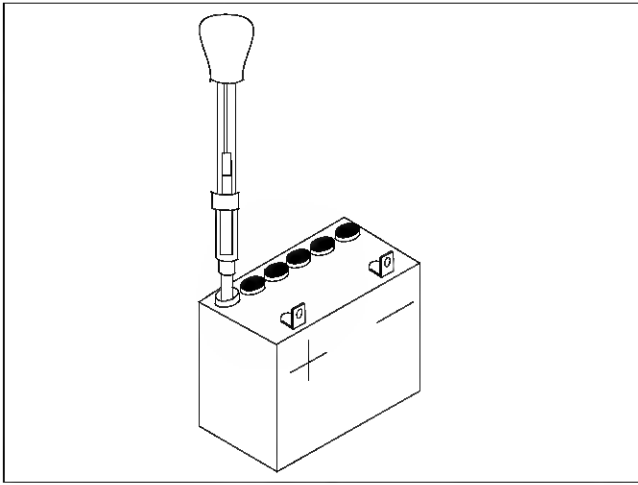
#### Equipment:

- Hydrometer
- Voltmeter or JTO5685 Battery Tester

#### Procedure:

1. Park machine Safely with park brake locked. See "Park Machine Safely" in the Safety section.
2. Raise hood.
3. Clean cable ends, battery terminals and top of battery.
4. Remove battery to workbench.
5. Inspect battery terminals and case for breakage or cracks.

# ELECTRICAL TESTS AND ADJUSTMENTS



6. Check electrolyte level in each battery cell. Add distilled water as needed. If water is added, charge battery for 20 minutes at 10 amps.

7. Remove surface charge by placing a small load on the battery for 15 seconds.

8. Use a hydrometer to check for a minimum specific gravity of 1.225 with less than 50 point variation in each cell.

## Results:

- If all cells are less than 1.175, charge battery at 10 amp rate.
- If all cells are less than 1.225 with less than 50 point variation, charge battery at 10 amp.
- If all cells are more than 1.225 with less than 50 point variation, load test battery.
- If more than 50 point variation, replace battery.
- Use a voltmeter or JTO5685 Battery Tester to check for a minimum battery voltage of 12.4 volts.

## Results:

- If battery voltage is less than 12.4 VDC, charge battery See "Charge Battery" on page 344.
- If battery voltage is more than 12.4 VDC, test specific gravity.

## Charge Battery

### Reason:

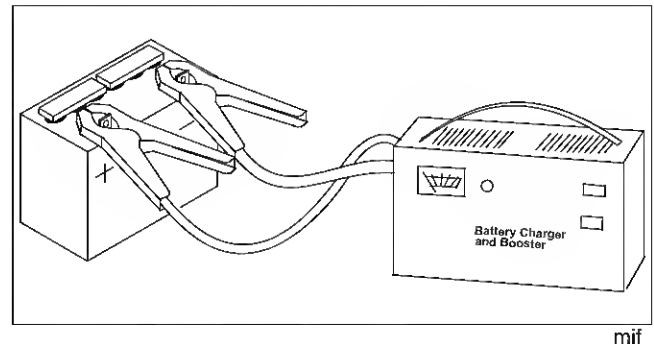
To increase battery charge after the battery has been discharged.

### Equipment:

- Battery charger (variable rate)

### Procedure:

1. Park machine Safely with park brake locked. See "Park Machine Safely" in the Safety section.
2. Raise hood.
3. Clean cable ends, battery terminals and top of battery.
4. Remove battery to workbench.



5. Connect variable rate charger to battery.
6. Start charger at SLOW rate. Increase charge rate ONE setting at a time. Check charger ammeter after 1 minute at each setting. Maintain 10 amp charge rate. Use boost setting as necessary.
7. Check if battery is accepting 10 amp charge rate after 10 minutes at boost setting.

### Results:

- If battery WILL NOT accept 10 amp charge after 10 minutes at boost setting, replace battery;
- If battery is accepting 10 amp charge after 10 minutes at boost setting, and battery did NOT need water, go to next steps.
- If battery is accepting 10 amp charge after 10 minutes at boost setting, but battery DID need water or all cells were BELOW 1.175, go to next step.

**Important: Avoid Damage! Decrease charge rate if battery gases or bubbles excessively or becomes too warm to touch.**

- a. Set charger at 15 - 25 amps.
- b. Check specific gravity after 30 minutes (60 minutes for maintenance-free battery).



# ELECTRICAL TESTS AND ADJUSTMENTS

## Results:

- If MORE THAN 50 point variation between cells, replace battery;
- If LESS THAN 50 point variation between cells, go to next steps.

**Note:** If battery was discharged at slow or unknown rate, charge battery at 10 - 15 amps for 6 - 12 hours. (Maintenance-free battery: 4 - 8 hours).

- a. Continue to charge battery until specific gravity is 1.250 - 1.265 points.
- b. Load test battery.
- c. Install battery.

## Battery Load Test

### Reason:

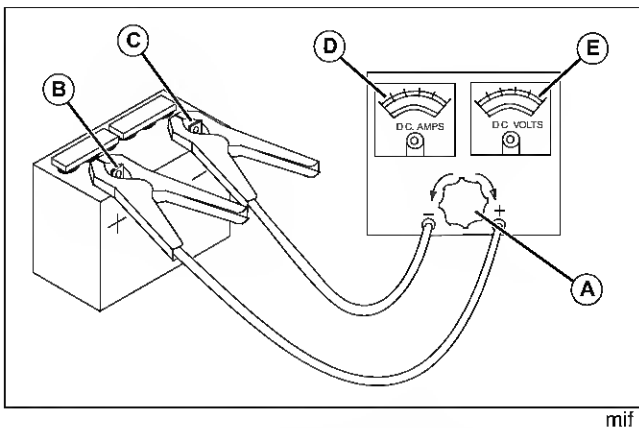
To check condition of battery under load.

### Equipment:

- JTO5685 Battery Tester

### Procedure:

1. Park machine Safely with park brake locked. See "Park Machine Safely" in the Safety section.
2. Raise hood.
3. Clean cable ends, battery terminals and top of battery.
4. Remove battery.



5. Turn load knob (A) counterclockwise to OFF position.
6. Connect tester positive (red) cable to battery positive (+) terminal (B).
7. Connect tester negative (black) cable to battery negative (-) terminal (C).
8. Turn load knob (A) of tester clockwise (in) until amperage reading (D) is equal to:

- Cold cranking amperage rating of battery (use blue scale), or
- Three times ampere hour rating (use black scale).

9. Hold for 15 seconds and turn load knob (A) of tester counterclockwise to OFF position.

10. Repeat Steps 8 and 9 above and read condition of battery at DC Volts scale (E).

### Results:

- If battery DOES NOT pass test and has NOT been charged, charge battery and retest.
- If battery DOES NOT pass test and HAS BEEN charged, replace battery.

## Regulated Voltage Test

### Reason:

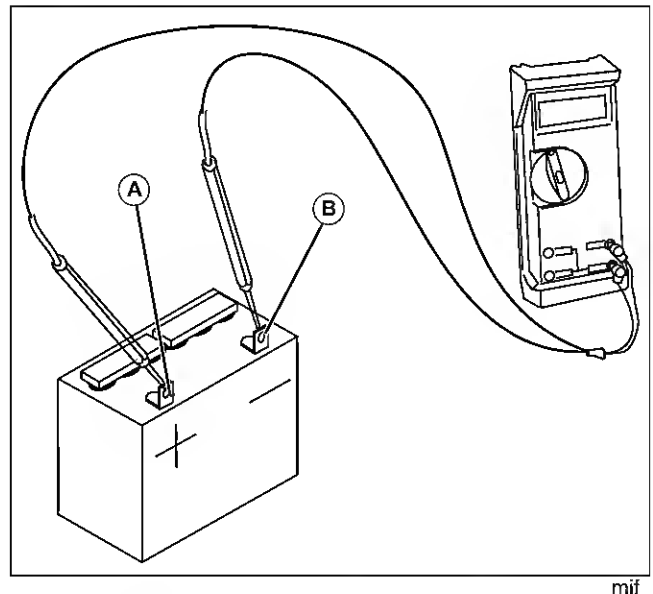
To determine regulated voltage output of the regulator/rectifier.

### Equipment:

- Multimeter

### Procedure:

1. Park machine Safely with park brake locked. See "Park Machine Safely" in the Safety section.
2. Raise hood.
3. Remove surface charge from battery by placing a small load on the battery for 15 seconds.
4. Set voltmeter to 50 DC volt scale.



5. Connect voltmeter positive (red) lead to battery positive (+) terminal (A).

# ELECTRICAL TESTS AND ADJUSTMENTS

6. Connect voltmeter negative (black) lead to battery negative (-) terminal (B).
7. Start and run engine at fast idle. Read voltmeter several times during 5 minutes of running time.
8. Voltage should remain between 12.2 - 14.7 volts DC.

## Results:

- If the DC voltage remains below the minimum specification, test stator voltage output.
- If the DC voltage goes above the maximum specification, replace the regulator/rectifier.

## Regulated Amperage Test

### Reason:

To determine charging output of rectifier/regulator.

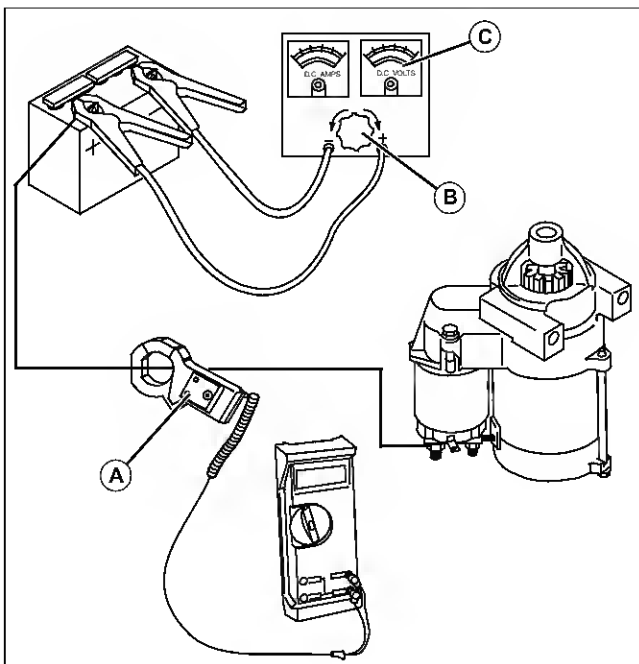
### Equipment:

- Multimeter
- JT05712 Current Gun
- JT05685 Battery Tester

### Procedure:

1. Park machine Safely with park brake locked. See "Park Machine Safely" in the Safety section.
2. Raise hood.

**Note: Battery must be in a good state of charge at 12 to 15 VDC.**



mif

3. Connect JTO5712 Current Gun (A) to voltmeter and put around positive (red) battery cable going to starting motor.
4. Set current gun for DC current.

**Note: Turn load knob (A) fully counterclockwise (out) into OFF position BEFORE making any test connections.**

5. Connect battery tester to battery.

**Note: Perform this test quickly to prevent damage to battery tester. DO NOT apply full load to battery for more than 5 - 10 seconds.**

6. Turn load knob (B) clockwise (in) until voltage on voltage tester scale reads 11 volts for 5 seconds only to partially drain battery.
7. Quickly turn load knob completely counter-clockwise (out) to OFF position.
8. Start and run engine at fast idle. Battery voltage should read between 12.2 - 15.0 VDC.
9. Turn load knob clockwise (in) until voltage on tester voltage scale (B) reads 11 volts and observe reading on amps scale.
10. Quickly turn load knob completely counter-clockwise (out) to OFF position.
11. After load test, voltage scale (B) should return to voltage level prior to test.

## Results:

- If reading does not meet specifications, test stator voltage output. See "Stator Output Test" on page 347.

If stator voltage output meets specifications and voltage and ground to the regulator/rectifier is verified, replace the regulator/rectifier.

## Specifications:

**Minimum load reading . . . . . 13.5 amps at 11 volts**

# ELECTRICAL TESTS AND ADJUSTMENTS

## Voltage Regulator/Rectifier Test

### Reason:

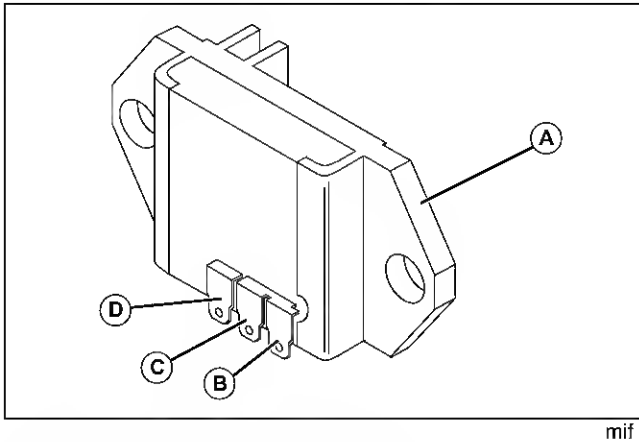
To verify proper operation capability of the voltage regulator/rectifier.

### Equipment:

- Multimeter

### Procedure:

1. Park machine Safely with park brake locked. See "Park Machine Safely" in the Safety section.
2. Raise hood.
3. Disconnect stator connector from the voltage regulator/rectifier.
4. Set the multi-meter to the Ohms scale.



5. Measure resistance between each point as shown in the chart.

	A	B	C	D
A		OL	OL	OL
B	1.83 m		0.0	OL
C	1.83 m	0.2		OL
D	3.0 m	OL	OL	

6. If resistance is not within specification, replace voltage regulator/rectifier.

## Stator Output Test

### Reason:

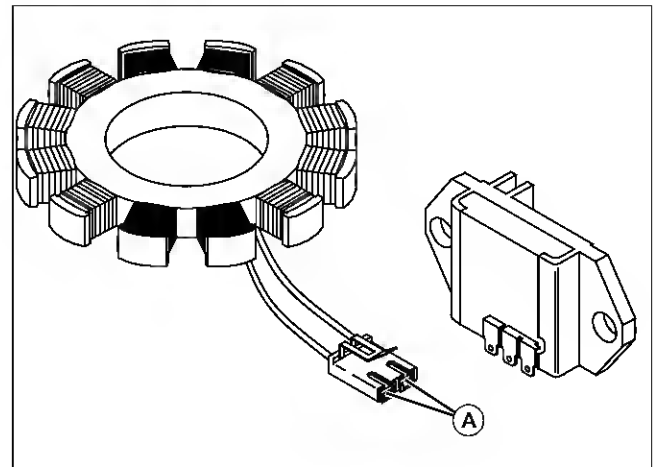
To measure AC voltage output of stator.

### Equipment:

- Multimeter

### Procedure:

1. Park machine Safely with park brake locked. See "Park Machine Safely" in the Safety section.
2. Raise hood.
3. Disconnect stator connector from voltage regulator/rectifier.
4. Set multimeter for AC volts.



5. Attach RED test lead to either pin on stator side of stator connector (A).
6. Attach BLACK test lead to other pin.
7. With parking brake locked, start engine and run at full throttle.
8. Check output.

### Results:

- Output to specification.
- If no or low output is found, replace stator.

### Specifications:

AC output at full throttle . . . . . 28 volts (minimum)

# ELECTRICAL TESTS AND ADJUSTMENTS

## Flywheel Stator Magnets Test

### Reason:

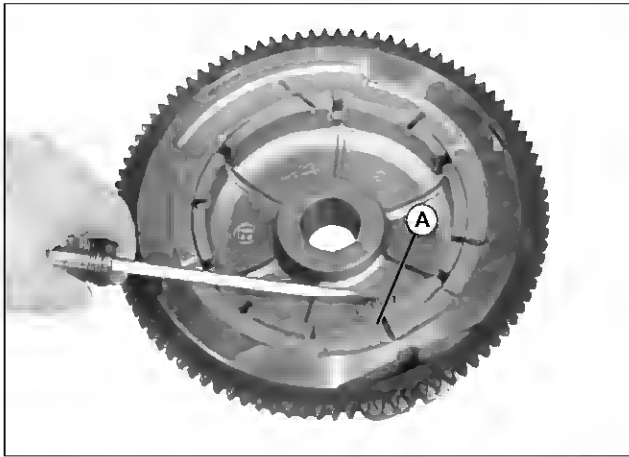
To make sure flywheel magnet have enough force to induce current into stator.

### Equipment:

- Screwdriver

### Procedure:

1. Park machine safely with park brake locked. See "Park Machine Safely" in the Safety section.
2. Raise hood.
3. Remove flywheel blower housing from engine.
4. Remove flywheel. See engine section.



MX37342

**Size of magnets may vary between models**

5. Loosely hold screwdriver blade about **25 mm (1.0 in.)** away from magnet (A).

### Results:

- Magnet should attract blade to it.
- If blade is NOT attracted to magnet, flywheel must be replaced.

## Flywheel Ignition Magnet Test

### Reason:

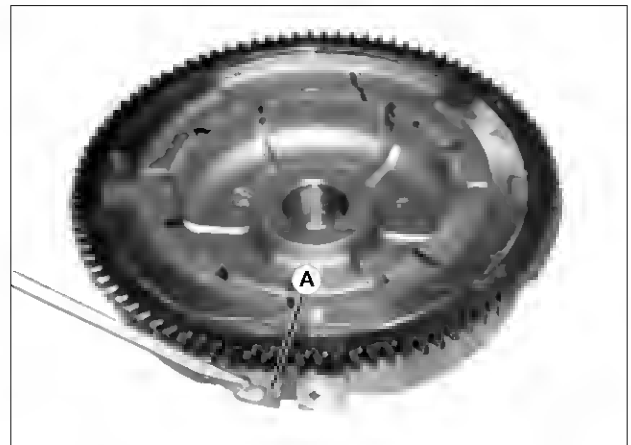
To make sure flywheel magnet(s) have enough force to induce current into ignition coil.

### Equipment:

- Screwdriver

### Procedure:

1. Park machine safely with park brake locked. See "Park Machine Safely" in the Safety section.
2. Raise hood.
3. Remove flywheel blower housing from engine.



MX37343

**Flywheel removed for clarity**

4. Loosely hold screwdriver blade about **25 mm (1.0 in.)** away from magnet (A).

### Results:

- Magnet should attract blade to it.
- If blade is NOT attracted to magnet, flywheel must be replaced.

# ELECTRICAL TESTS AND ADJUSTMENTS

## Spark Test

### Reason:

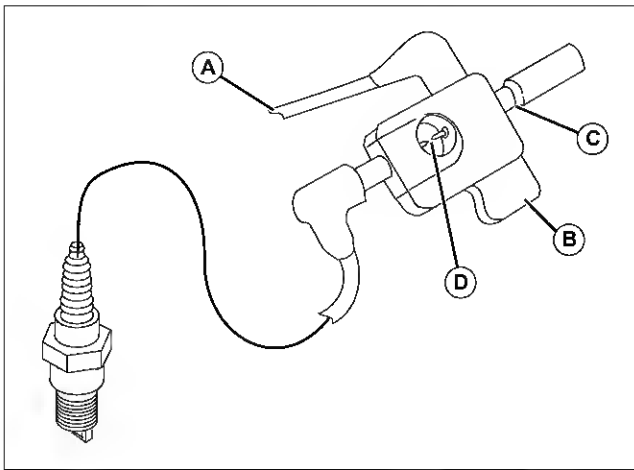
Check overall condition of ignition system.

### Equipment:

- D-05351ST Spark Tester

### Connections:

1. Park machine Safely with park brake locked. See "Park Machine Safely" in the Safety section.
2. Raise hood.



3. Remove high tension lead (A) from spark plug and connect to spark tester (B).
4. Connect spark tester to spark plug.
5. Adjust spark tester gap to 4.2 mm (0.166 in.) with screw (C).

**Important: Avoid Damage! Do not adjust spark tester gap beyond 5.0 mm (0.200 in.) as damage to ignition system components could occur.**

### Procedure:

1. Turn key switch to start position and watch spark (D) at spark tester. If engine will start, watch spark with engine running.

### Specifications:

- Steady, strong, blue spark.

### Results:

- If spark is weak, or if no spark, install a new spark plug and test again.
- If spark is still weak, or still no spark, run tests on individual components to find cause of malfunction.

## Starting Solenoid Test

### Reason:

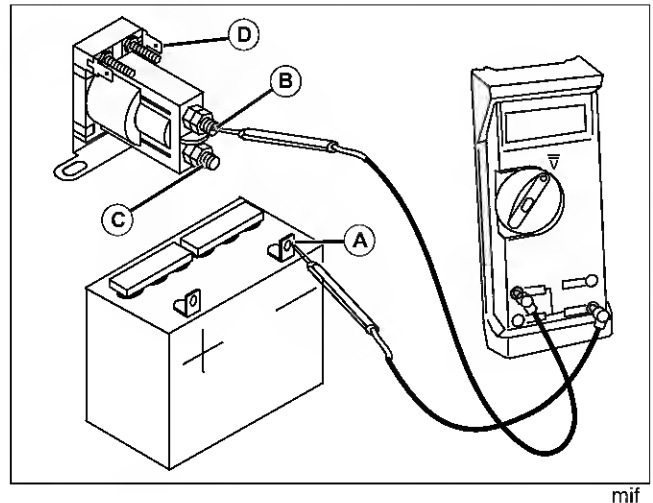
To determine if starting solenoid is defective.

### Equipment:

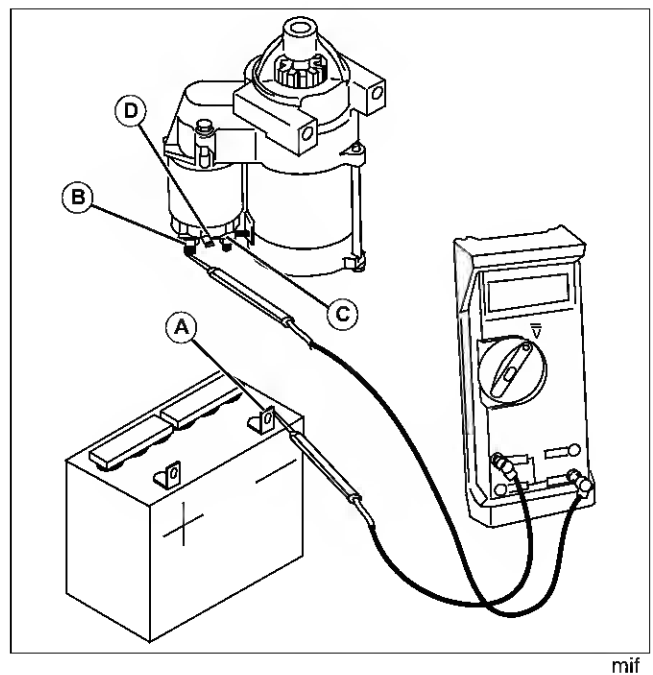
- Volt Ohm Meter

### Procedure:

1. Park machine safely with park brake locked. See "Park Machine Safely" in the Safety section.
2. Raise hood.
3. Disconnect and ground spark plug leads.



### X300 and X304



### X320, X324, and X340

# ELECTRICAL TESTS AND ADJUSTMENTS

4. Connect VOM to negative (-) battery terminal (A) and terminal (B) of starting motor solenoid. Check for battery voltage.

- No battery voltage - Check battery positive (+) terminal and starting motor solenoid terminal (B) for loose connections. Clean any corrosion.
- Battery voltage - go to next step.

5. Connect VOM to negative (-) battery terminal (A) and terminal (C) of starting motor solenoid.

6. Momentarily turn ignition key to START position and check for battery voltage.

- Battery voltage - starting motor solenoid is not defective.
- No battery voltage - go to next step.

7. Connect VOM to negative (-) battery terminal (A) and terminal (D) (Pur wire) of starting motor solenoid.

8. Momentarily turn ignition key to START position and check for battery voltage.

- No battery voltage - Check Pur wire and connections. See appropriate cranking circuit diagnosis in this section.
- Battery voltage - Check Blk wire and connections between starting motor solenoid and frame ground. If OK, starting motor solenoid is defective, replace solenoid.

## Starting Motor Amperage Draw Test - Loaded

### Reason:

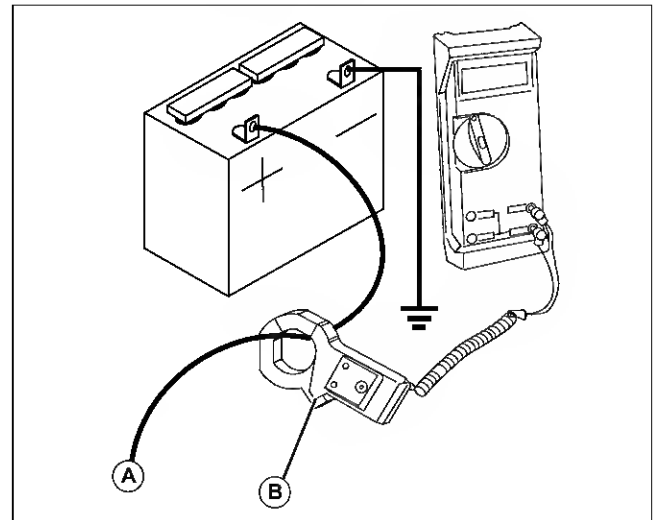
To determine amperage needed to crank the engine.

### Required Tools:

- JT05791 Multimeter
- JT02153 Current Clamp

### Procedure:

1. Park machine Safely with park brake locked. See "Park Machine Safely" in the Safety section.
2. Raise hood.
3. Remove spark plug lead and ground to engine.
4. Connect current clamp RED lead to the VOLTS jack of the multimeter and the BLACK lead of the current clamp to the COM jack on the multimeter.



### To starter solenoid

5. Clamp jaws of current clamp (B) around the positive battery cable.

6. Set the current clamp to 2000A and the multimeter to 300mV.

**Note:** The core of the jaws may hold some magnetic force after the current clamp has been used for measurement. If you cannot zero adjust the display, open the jaws and snap them closed several times.

7. Adjust the DCA ZERO ADJUST dial on the current clamp for a zero reading on the multimeter.

**Note:** If using a multimeter other than JT05791, use a meter that will read millivolts. Millivolts = current in amps; 1m V= 1 amp.

8. Crank the engine and read the starting motor amperage draw.

### Result:

- If amperage is above specification check starting motor for binding or damaged wires or windings.
- If starting motor is good, check internal engine and PTO drive for binding or damage.

### Specifications:

**Maximum starting motor amp draw - X300 and X304**  
.....100 amps  
**Maximum starting motor amp draw - X320, X324, and X340.** .....180 amps

# ELECTRICAL TESTS AND ADJUSTMENTS

## Starting Motor Amperage Draw Test - No-Load

### Reason:

To determine starting motor condition under no-load conditions.

### Required Tools:

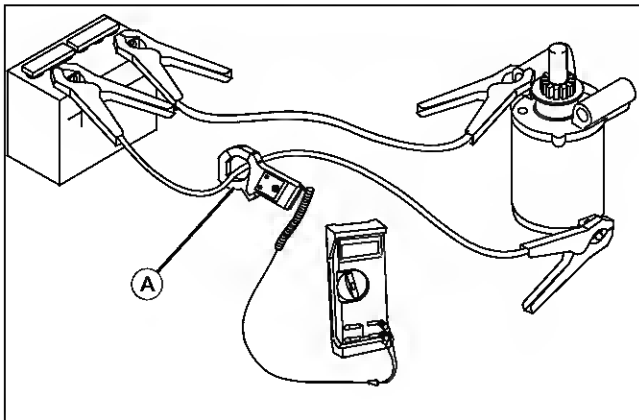
- JT05791 Multimeter
- JT02153 Current Clamp
- 12 Volt Battery
- Jumper Cables

### Procedure:



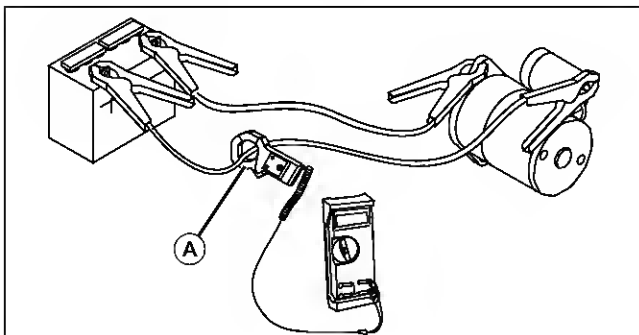
**Caution: Avoid Injury! Do not clamp starting motor housing in vise or strike with a hammer. Clamp only on the mounting bracket. Starting motors contain two ceramic magnets that can be broken or cracked if the motor housing is hit, deformed or dented.**

1. Remove starting motor from machine and clamp the starting motor mounting bracket in a vise.



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Picture Note: X300 and X304



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Picture Note: X320, X324, and X340

2. Connect current clamp (A) RED lead to the VOLTS jack

of the multimeter and the BLACK lead of the current clamp to the COM jack on the multimeter.

3. Connect the negative jumper cable to the battery negative post and the frame of the starting motor.
4. Connect the positive jumper cable to the positive post of the battery.
5. Connect current clamp RED lead to the VOLTS jack of the multimeter and the BLACK lead of the current clamp to the COM jack on the multimeter.
6. Clamp jaws of current clamp around the positive jumper cable.
7. Set the current clamp to 2000A and the multimeter to 300mV.

**Note: The core of the jaws may hold some magnetic force after the current clamp has been used for measurement. If you cannot zero adjust the display, open the jaws and snap them closed several times.**

8. Adjust the DCA ZERO ADJUST dial on the current clamp for a zero reading on the multimeter.

**Note: If using a multimeter other than JT05791, use a meter that will read millivolts. Millivolts = current in amps; 1mV = 1 amp.**

9. Momentarily touch the positive jumper cable lead to the starting motor positive post and read the starting motor amperage draw.

### Result:

- If amperage is above specification, check starting motor for binding or damage.

### Specifications:

**Maximum starting motor amp draw -**

**X300 and X304 ..... .50 amps**

**Maximum starting motor amp draw -**

**X320, X324, and X340. .... .35 amps**

# ELECTRICAL TESTS AND ADJUSTMENTS

## Relay Test (SN 040001-)

### Reason:

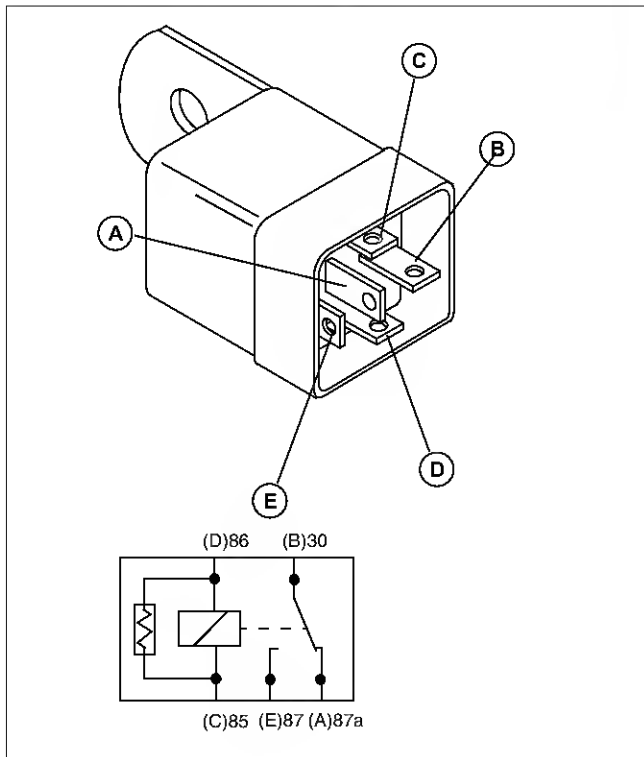
To check relay terminal continuity in the energized and de-energized condition.

### Equipment:

- Ohmmeter or continuity tester

### Procedure:

1. Park machine on level surface.
2. Engage park brake.
3. Turn key switch OFF.
4. Disconnect relay connector.



5. Check terminal continuity using an ohmmeter or continuity tester.

- There should be continuity between terminals (A) and (B), and between terminals (C) and (D).
- There should NOT be continuity between terminals (E) and (B).

6. Connect a jumper wire from battery positive (+) terminal to relay terminal (C). Connect a jumper wire from relay terminal (D) and ground (-).

- There should be continuity between terminals (E) and (B).
- If continuity is NOT correct, replace relay.

## Fuel Shutoff Solenoid Test

### Reason:

To determine if the fuel shutoff plunger retracts when the solenoid is energized.

### Test Equipment:

- 2 Jumper wires

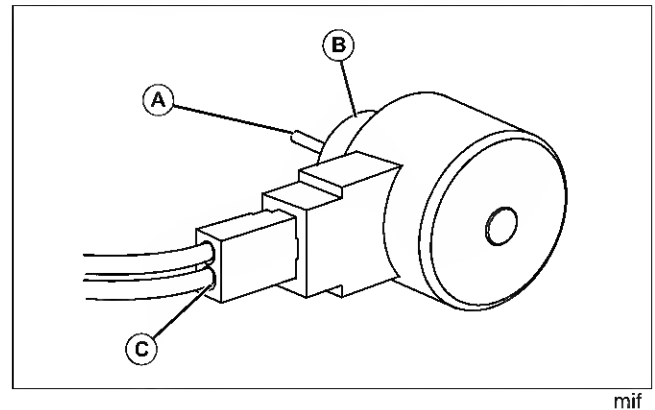
### Procedure:

1. Park machine Safely with park brake locked. See "Park Machine Safely" in the Safety section.
2. Raise hood.



**Caution: Avoid Injury! Keep gasoline away from sparks, flame, or hot engine parts or personal injury can result.**

3. Remove drain screw and spring to drain gasoline from float bowl.
4. Disconnect fuel shutoff solenoid connector.
5. Remove fuel shutoff solenoid, washer and float bowl.



6. Connect a jumper wire from the battery positive (+) terminal to solenoid terminal (C).

**Note: It may be necessary to push plunger (A) inward slightly for plunger to retract.**

7. Connect a jumper wire from the battery negative (-) terminal to solenoid threads (B). Plunger should now retract with the solenoid energized.
8. Remove jumper wire from the battery negative (-) terminal. Plunger should extend.

### Results:

- If plunger does not move, replace solenoid.



# ELECTRICAL TESTS AND ADJUSTMENTS

## PTO/RIP Switch Test

### Reason:

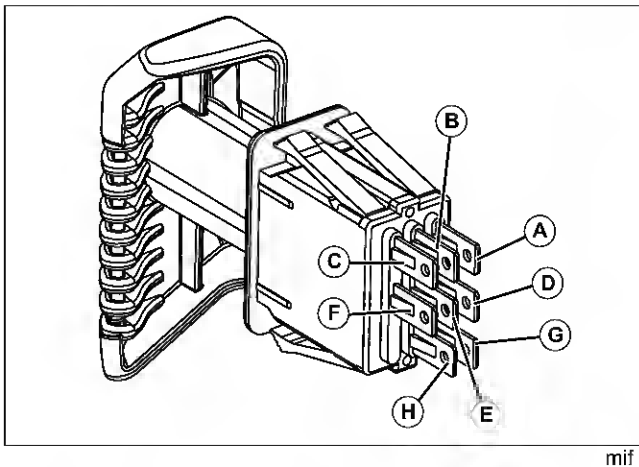
To verify terminal continuity is correct when in the ON and OFF positions.

### Test Equipment:

- Ohmmeter or continuity tester

### Procedure:

1. Park machine Safely with park brake locked. See "Park Machine Safely" in the Safety section.
2. Raise hood.
3. Disconnect PTO/RIP switch connector.
4. Verify the PTO/RIP switch is in the OFF position.



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5. Use an ohmmeter to test switch continuity in OFF, ON and MOMENTARY positions.

### PTO/RIP Switch Continuity:

Switch Position	Terminal continuity
OFF	A and C
	D and F
ON	A and B
	D and E
Momentary ON	A and B
	D and E
	G and H

### Results:

- All other possible combinations have infinite resistance. If any continuity is NOT correct, replace switch.

## PTO Clutch Test

### Reason:

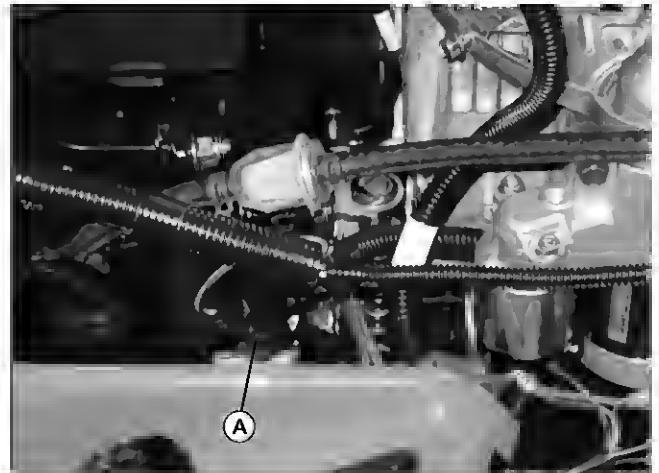
To check condition of PTO clutch coil and to check operation under load.

### Test Equipment:

- Volt/Amp/Ohmmeter
- 12 Volt Power Source

### Procedure:

1. Park machine Safely with park brake locked. See "Park Machine Safely" in the Safety section.
2. Raise hood.
3. Remove mower deck or any other PTO driven attachment.



MX36324

4. Disconnect PTO clutch connector (A).
5. Set multimeter to ohms scale.
6. Measure resistance across connector (A) terminals of clutch.
7. Connect PTO clutch connector.
8. Set multimeter to VDC scale.
9. Properly plug current clamp into multimeter then clamp it around the Red PTO clutch wire.
10. Have a helper start and run engine at FAST idle.
11. Have your helper turn the PTO/RIO Switch to the ON position.
12. Measure PTO clutch current draw.

### Specification:

Resistance	2.8 - 3.3 ohms
Amperage Draw	3.6 - 4.4 amps

# ELECTRICAL TESTS AND ADJUSTMENTS

## Results:

- If amperage draw DOES NOT meet specification, replace the PTO clutch.
- Normal amperage draw is approximately 4 amps. Low current draw will cause a weak PTO clutch. If the current draw is less than 3 amps, replace clutch.

## Headlight Switch Test (SN -040000)

### Reason:

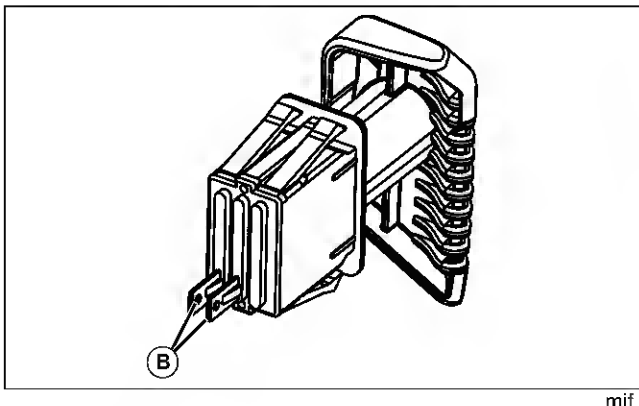
To verify headlight switch terminals have continuity when the headlight switch is ON.

### Test Equipment:

- Ohmmeter or continuity tester

### Procedure:

1. Park machine Safely with park brake locked. See "Park Machine Safely" in the Safety section.
2. Raise hood.
3. Disconnect headlight switch connector.



4. Connect ohmmeter leads to terminals (B) of switch.
5. Set ohmmeter for 1x ohms scale.
6. Move headlight switch to the ON position and then the OFF position. Check continuity between terminals.

### Results:

- If NO continuity with switch in ON position, replace switch.
- If continuity exists with switch in OFF position, replace switch.

## Fuse Test

### Reason:

To verify that the fuse has continuity.

### Equipment:

- Ohmmeter or continuity tester

### Procedure:

1. Park machine Safely with park brake locked. See "Park Machine Safely" in the Safety section.
2. Raise hood.
3. Remove fuse from connector.



4. Check visually for broken filament (A).
5. Connect ohmmeter or continuity tester to each end of fuse.
6. Check for continuity.

### Results:

- If continuity is not indicated, replace fuse.

# ELECTRICAL TESTS AND ADJUSTMENTS

## Bulb Test

### Reason:

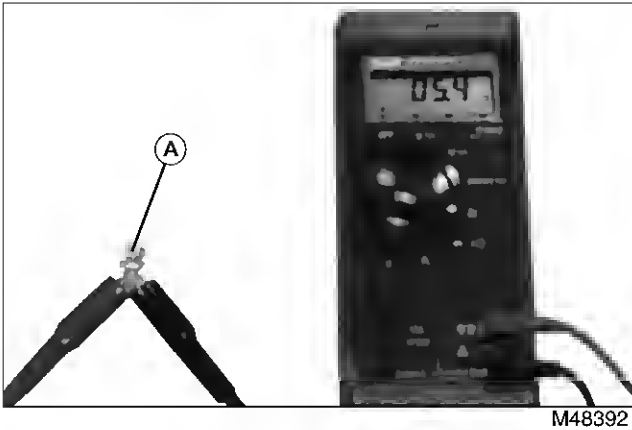
To verify that the bulb has continuity.

### Equipment:

- Ohmmeter or continuity tester

### Procedure:

1. Remove bulb from socket.



2. Check visually for broken filament (A).
3. Connect ohmmeter or continuity tester to each terminal of bulb.
4. Check for continuity.

### Results:

- If continuity is not indicated, replace bulb.

## Diode Test

### Reason:

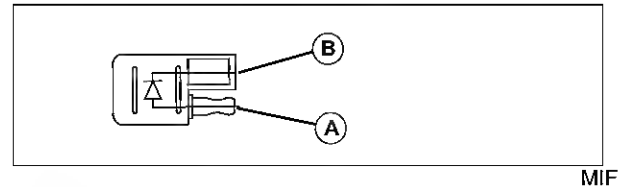
To verify that diode has proper continuity.

### Equipment:

- Ohmmeter or continuity tester

### Procedure:

1. Park machine safely in neutral with park brake locked.
2. Raise hood.
3. Remove diode from connector.



4. Connect ohmmeter red (+) lead to pin (A) of diode.
5. Connect ohmmeter black (-) lead to pin (B) of diode. Check for continuity.
6. Reverse test leads. Check for continuity.

### Results:

Diode must have continuity in one direction only. Replace defective diode.

# ELECTRICAL TESTS AND ADJUSTMENTS

## Brake Switch Test

### Reason:

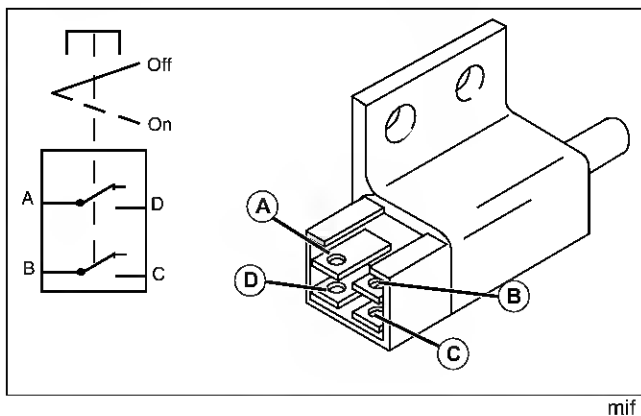
To determine proper operation of the brake switch.

### Equipment:

- Ohmmeter or continuity tester

### Test Procedure:

1. Park machine Safely with park brake locked. See "Park Machine Safely" in the Safety section.
2. Access the brake switch located under the front edge of the right side foot rest.
3. Remove connector from the brake switch. Remove switch if needed to access terminals properly.



4. Connect meter leads to pairs of switch posts and compare to specifications.
5. Press and release plunger of switch.

### Switch plunger off (not pressed)

..... no continuity between any terminals

### Switch plunger on (pressed)

..... continuity between A and D  
..... continuity between B and C

### Results:

- If continuity is not correct, or exists in any other combination than shown above, replace the brake switch.

## Hood Switch Test

### Reason:

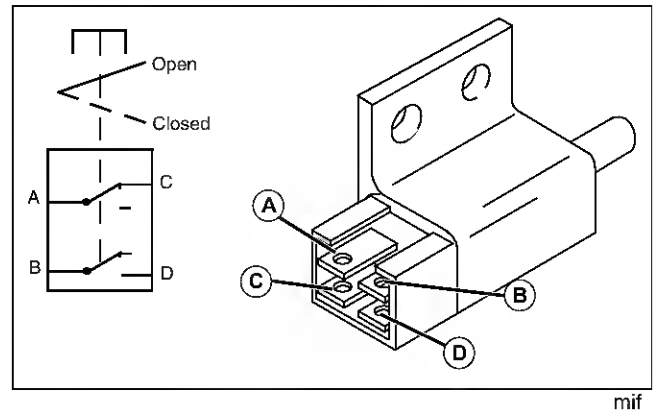
To determine proper operation of the hood switch.

### Equipment:

- Ohmmeter or continuity tester

### Test Procedure:

1. Park machine Safely with park brake locked. See "Park Machine Safely" in the Safety section.
2. Remove connector from the switch. Remove switch if needed to access terminals properly.



3. Connect meter leads to pairs of switch posts and compare to specifications.
4. Press and release plunger of switch.

### Switch plunger off (not pressed)

..... continuity A and C  
..... no continuity B and D

### Switch plunger on (pressed)

..... no continuity A and C  
..... continuity B and D

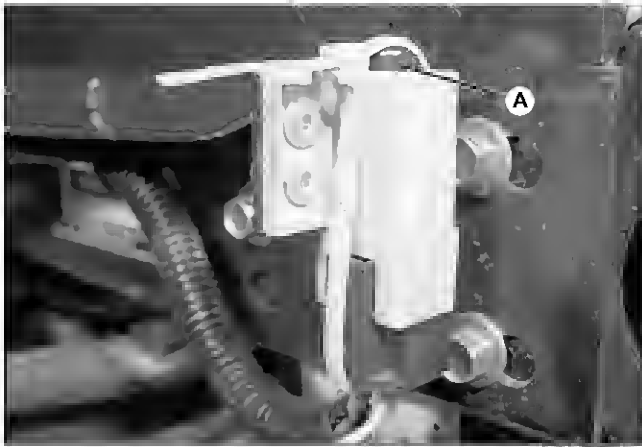
### Results:

- If continuity is not correct, or exists in any other combination than shown above, replace the brake switch.

### Hood Switch - Manual Close for Tests:

1. Remove hood.

# ELECTRICAL TESTS AND ADJUSTMENTS



2. Hold the switch plunger (A) down with a tie wrap or with tape.

## Reverse Switch Test and Adjustment

### Reason:

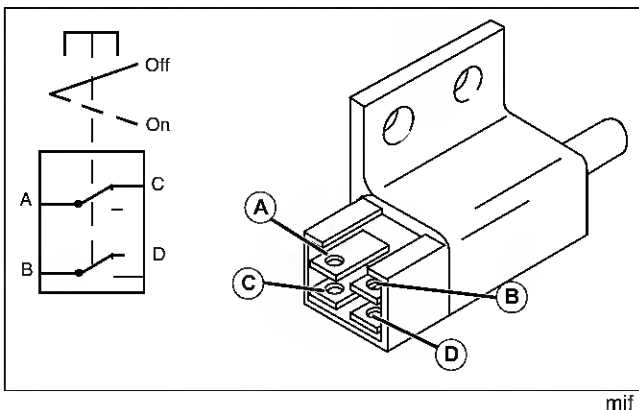
To determine proper operation of the reverse switch.

### Equipment:

- Ohmmeter or continuity tester

### Test Procedure:

1. Park machine Safely with park brake locked. See "Park Machine Safely" in the Safety section.
2. Access the brake switch located under the right side foot rest.
3. Remove connector from the reverse switch. Remove switch if needed to access terminals properly.



4. Connect meter leads to pairs of switch posts and compare to specifications.
5. Press and release plunger of switch.

### Switch plunger off (not pressed)

.....continuity A and C

..... no continuity B and D

### Switch plunger on (pressed)

..... no continuity A and C

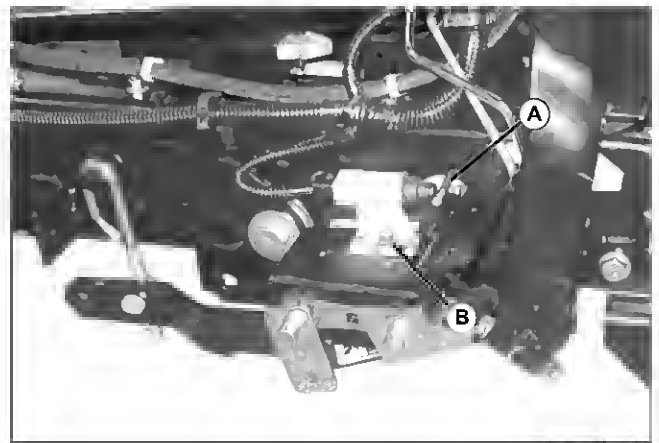
..... continuity B and D

### Results:

- If continuity is not correct, or exists in any other combination than shown above, replace the reverse switch.

### Adjustment Procedure:

1. Remove fender deck. See "Fenderdeck Removal and Installation" on page 566.
2. Install the drive pedals hand tight.



3. Press and release the forward pedal, then press and release the reverse pedal.
4. The contact rod (A) should just touch the reverse switch plunger without causing the plunger to be depressed.
5. If the plunger is being depressed, or if there is a gap between the plunger and the contact rod, loosen the cap screw (B) and slide the switch bracket assembly forward or rearward until the plunger just touches the contact rod.
6. Hold the switch bracket assembly in position and tighten the cap screw.
7. Press and release the forward pedal, then press and release the reverse pedal. Recheck the adjustment.
8. Remove the drive pedals.
9. Install the fender deck. See "Fenderdeck Removal and Installation" on page 566.

# ELECTRICAL TESTS AND ADJUSTMENTS

## Seat Switch Test (SN -040000)

### Reason:

To determine proper operation of seat switch.

### Equipment:

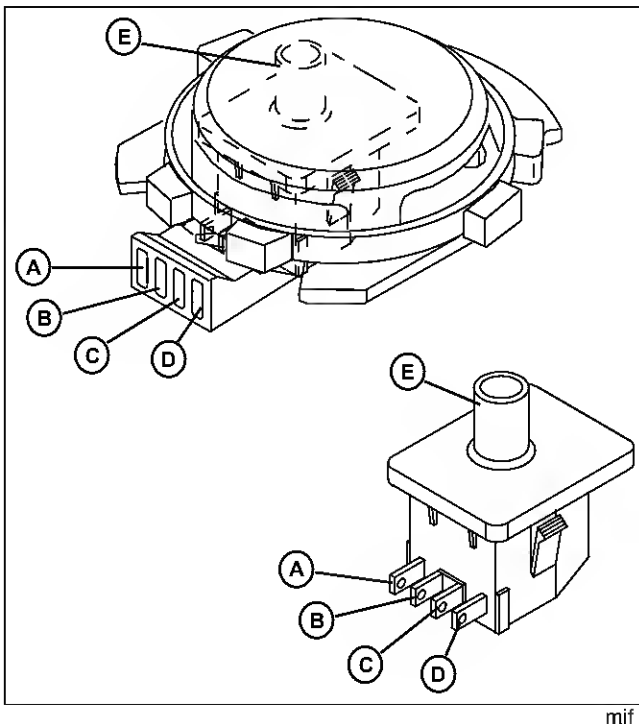
- Ohmmeter

### Test Connections:

- Set ohmmeter for 1X ohms scale

### Procedure:

1. Park machine Safely with park brake locked. See "Park Machine Safely" in the Safety section.
2. Remove connector from seat switch.



3. Connect meter leads to pairs of switch posts and compare to specifications.

4. Press and release seat switch plunger (E).

### Results:

- If the seat switch does not pass tests, replace switch

### Specifications:

#### Seat switch plunger not pressed

..... continuity between B and C

..... continuity between A and D

#### Seat switch plunger pressed

..... no continuity between any terminals

## Seat Switch Test (SN 040001-)

### Reason:

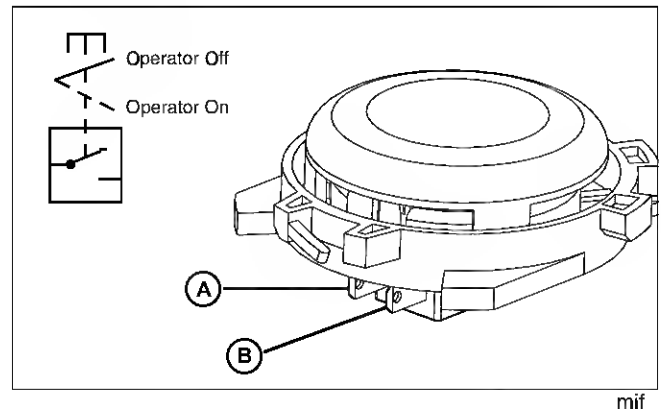
To verify that seat switch functions properly.

### Equipment:

- Ohmmeter or continuity tester

### Procedure:

1. Park machine safely with park brake locked.
2. Raise seat.
3. Disconnect seat switch from wiring harness.



4. Check continuity across switch terminals (A and B). There should be no continuity.

5. Depress seat switch plunger. Continuity should exist between terminals (A and B).

### Results:

- If continuity is not correct, replace seat switch.

# ELECTRICAL TESTS AND ADJUSTMENTS

## Key Switch Test (SN -040000)

### Reason:

To determine proper operation of the key switch.

### Equipment:

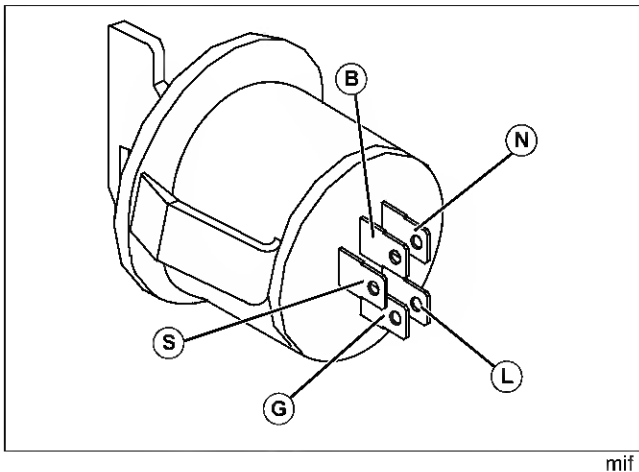
- Ohmmeter

### Test Conditions:

- Set Ohmmeter for 1X Ohms scale.
- Remove connector from back of key switch.

### Procedure:

1. Park machine Safely with park brake locked. See "Park Machine Safely" in the Safety section.
2. Raise hood.



3. Connect meter leads to pairs of switch posts and compare to specifications.
4. For ignition circuit, turn key switch from off to run position.
5. For starting circuit, turn key switch from run to start position.

### Specifications:

#### Switch in OFF

..... continuity between N and G

#### Switch in RUN

..... continuity between B and L

#### Switch in START

..... continuity between B and L  
..... continuity between B and S  
..... continuity between S and L

## Key Switch Test (SN 040001-)

### Reason:

To determine proper operation of key switch.

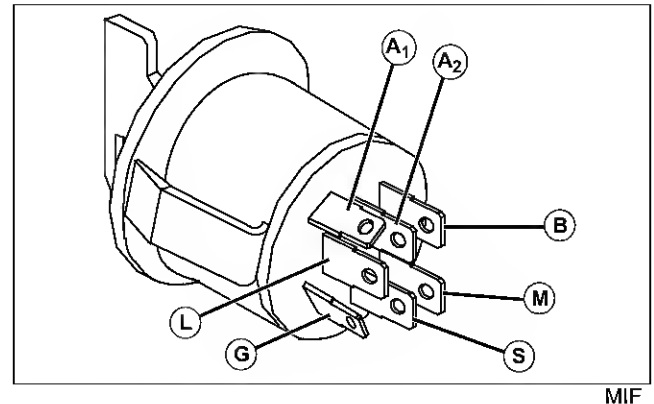
### Equipment:

- Ohmmeter

### Test Conditions:

- Set ohmmeter for 1X ohms scale.
- Remove connector from back of key switch.

### Procedure:



1. Connect meter leads to pairs of switch posts and compare to specifications.
2. For ignition circuit, turn key switch from OFF to RUN position.
3. For starting circuit, turn key switch from RUN to START position.

### Results:

- If key switch does not pass all tests, replace switch.

### Specifications:

#### Switch in OFF (Stop)

..... continuity between M, G, and A1

#### Switch in RUN 1 (With Lights)

..... continuity between B and A1  
..... continuity between L and A2

#### Switch in RUN 2 (Without Lights)

..... continuity between B and A1

#### Switch in START

..... continuity between B, S, and A1

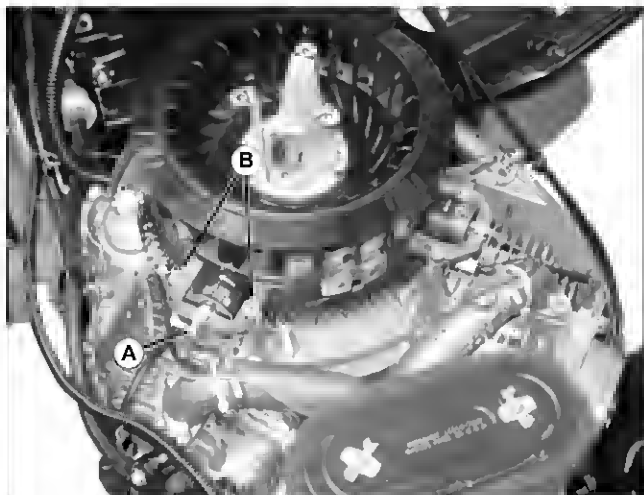
# ELECTRICAL REPAIR

## Repair

### Ignition Coil Replacement and Adjustment

#### Removal:

1. Park machine Safely with park brake locked. See "Park Machine Safely" in the Safety section.
2. Raise hood.
3. Remove flywheel blower housing from engine.
4. Disconnect plug wire from spark plug.



MX36322

5. Disconnect ignition lead from primary coil terminal (A).
6. Remove ignition coil mounting capscrews (B).

#### Installation:

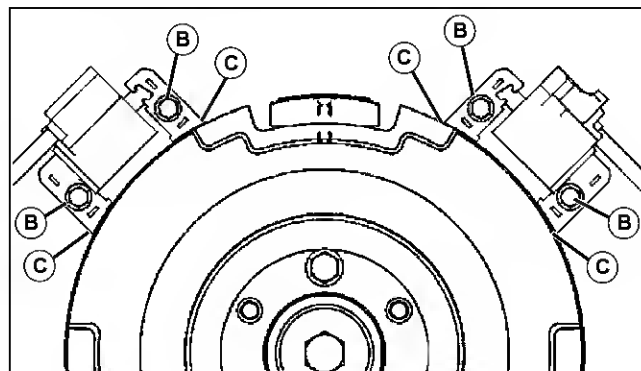
1. Align ignition coil with mounting holes on crankcase.
2. Loosely install mounting capscrews (B).
3. Connect ignition lead from primary coil terminal (A).
4. Connect plug wire to spark plug.
5. Adjust the ignition coil.

#### Equipment:

- Flat bladed feeler gauge.

#### Adjustment:

**Important: Avoid Damage! The engine is very sensitive to this adjustment so both legs of coil must have the same air gap.**



MX14236

1. Select the 0.3 mm (0.012 in.) feeler gauge blade and insert it between flywheel and coil legs (C).
2. Turn flywheel until magnet aligns with legs of ignition coil and feeler gauge spans both legs of coil and the flywheel magnet at the same time.
3. Hold ignition coil in place and tighten the mounting capscrews (B) to 3.4 N•m (30 lb-in.).

**Note: If a misfire condition exists, adjust air gap to a minimum of 0.25 mm (0.010 in.) to increase magnetic force.**

4. Check air gap again after tightening. Readjust if needed.

#### Specifications:

**Air Gap** ..... 0.25 - 0.40 mm (0.010 - 0.016 in.)

**Flanged Capscrew Torque** ..... 5.9 N•m (52 lb-in.)



# ELECTRICAL REPAIR

## Stator Replacement

**Note:** The charging system is a permanent magnet and stator design. As the flywheel rotates, a permanent magnet in the flywheel induces AC current in the stator windings. This current flows to the regulator-rectifier where it is converted to DC current needed to charge the battery. Component may differ from illustration.

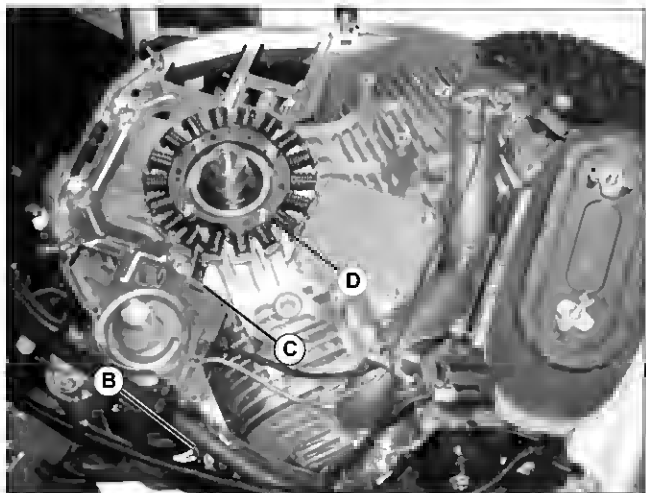
### Removal:

1. Park machine Safely with park brake locked. See "Park Machine Safely" in the Safety section.
2. Raise hood.
3. Remove engine blower housing.



MX36322

4. Hold flywheel with strap and remove flywheel bolt (A).
5. Remove the debris screen mount, spacer, and blower fan.
6. Use an appropriate flywheel puller and remove the flywheel.

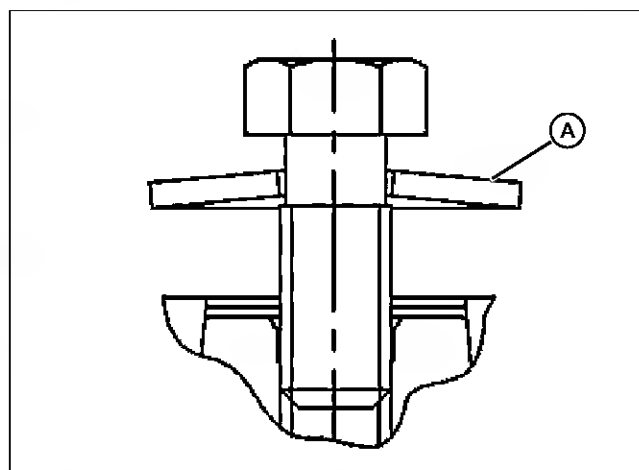


MX36323

7. Disconnect the stator wires (B) from the voltage regulator/rectifier.
8. Lift the wire retainer tab (C) and route the stator wires to the top of the shroud.
9. Remove the four mounting cap screws (D) and remove stator from crankcase.

### Installation:

1. Place stator over crankshaft and onto crankcase.
2. Align the four mounting holes with the threaded holes in the crankcase and the stator wires routed under the retainer tab.
3. Install and tighten the four cap screws.
4. Connect stator wires to the voltage regulator/rectifier.
5. Align the flywheel keyway with the key on the crankshaft and install flywheel.



MX16079

6. Install spring washer (A) as shown.
7. Install and tighten the flywheel bolt.
8. Install engine blower housing.

### Specifications:

Stator Capscrew . . . . . 3.4 N•m (30 lb-in.)  
Flywheel Bolt . . . . . 56 N•m (41 lb-ft)

# ELECTRICAL REPAIR

---



# POWER TRAIN - HYDROSTATIC TABLE OF CONTENTS

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# POWER TRAIN - HYDROSTATIC SPECIFICATIONS

## Specifications

### General Specifications

#### Transaxle

Drive Train .....	Belt Drive Transaxle with foot-controlled variable speed drive
Transaxle Control .....	Dual Pedal Automatic
Cruise Control .....	Standard
Type (X300 SN -040000) .....	Tuff Torq® K46BC Transaxle
Type (X300 SN 040001-040937) <sup>1</sup> .....	Tuff Torq® K46BR Transaxle
Type (X300 SN 040938-) <sup>2</sup> .....	Tuff Torq® K46BR Transaxle
Type (X304 SN 085001-) .....	Tuff Torq® K46CC Transaxle
Type (X320 SN -085000/X340 SN -085000) .....	Tuff Torq® K58 Transaxle
Type (X304 SN -085000/X324 SN -085000) .....	Tuff Torq® K58B Transaxle
Type (X360 SN 085001-) .....	Tuff Torq® K58H Transaxle

#### Travel Speeds (SN -085000)

Travel Speed-Forward (X300/X304/X324) .....	0 - 8.85 km/h (0 - 5.5 mph)
Travel Speed-Forward (X320/X340) .....	0 - 9.93 km/h (0 - 5.8 mph)
Travel Speed-Reverse (X300) .....	0 - 6.44 km/h (0 - 4.0 mph)
Travel Speed-Reverse (X304/X320/X324/X340) .....	0 - 5.63 km/h (0 - 3.5 mph)

#### Travel Speeds (SN 085001-)

Travel Speed-Forward (X300/X304/X324) .....	0 - 8.85 km/h (0 - 5.5 mph)
Travel Speed-Forward (X320/X340) .....	0 - 9.93 km/h (0 - 5.8 mph)
Travel Speed-Forward (X360) .....	0 - 9.98 km/h (0 - 6.2 mph)
Travel Speed-Reverse (X300/X304) .....	0 - 6.44 km/h (0 - 4.0 mph)
Travel Speed-Reverse (X320/X324/X340/X360) .....	0 - 5.63 km/h (0 - 3.5 mph)

#### Brake

Brake Type .....	Wet Disk
Brake Arm Force (K46) .....	250 N (56 lb)
Brake Arm Force (K58) .....	420 N (94 lb)
Brake Lever Travel (Maximum) .....	30°
Brake Shoe to Brake Disk Clearance .....	0.80 - 1.30 mm (0.031 - 0.051 in.)

#### Capacity:

Transaxle Oil Capacity - K46 (approximately) .....	2.2 L (2.3 qt)
Transaxle Oil Capacity - K58 (approximately) .....	2.4 L (2.5 qt)
Transaxle Oil .....	10w30 Oil

#### Capacity:

Transaxle Oil Capacity - K58H (X360) (approximately) .....	2.8 L (3.0 qt)
Transaxle Oil .....	John Deere J20D Low Viscosity HY-GARD

1. Pulley (p/n MIU800685) with 2369.9 mm belt (p/n M152284)

2. Pulley (p/n MIU800783) with 2348.0 mm belt (p/n M151277)

# POWER TRAIN - HYDROSTATIC SPECIFICATIONS

## Adjustment Specifications

### Specification:

Under Side of Forward Pedal-to-Foot Mat Height .....	56 mm (2.2 in.)
Under Side of Reverse Pedal-to-Foot Mat Height .....	41 mm (1.6 in.)

## Torque Specifications

### Specifications:

Brake Pedal Mounting Bolts .....	60 N•m (44 lb-ft)
Case Half Bolts .....	18 N•m (216 lb-in.)
Center Case Cap Screw .....	43 N•m (32 lb-ft)
Cruise Control Cam Follower Cap Screw .....	23 N•m (17 lb-ft)
Cruise Control Pivot Cap Screw .....	32.5 N•m (24 lb-ft)
Drain Bolt .....	14.7 N•m (130 lb-in.)
Eccentric Nut .....	24.5 - 32 N•m (18 - 24 lb-ft)
Flat Idler Nut On Idler Arm Assembly .....	26 N•m (230 lb-in.)
Pedal Cap Screw .....	68 N•m (50 lb-ft)
Pedal Pivot Rod Lock Nut .....	45 N•m (33 lb-ft)
Rear Tie Rod End Lock Nut .....	60 N•m (44 lb-ft)
Rear Wheel Bolts .....	88 N•m (65 lb-ft)
Transaxle-to-Hitch Plate Mounting Bolts .....	32 N•m (24 lb-ft)
K46 Front Support Strap Bolt .....	33 N•m (24 lb-ft)
K58, K58H Front Support Strap Bolt .....	64 N•m (47 lb-ft)
Transaxle Fan Nut .....	30 N•m (22 lb-ft)

## Other Materials

### Other Material

Part No.	Part Name	Part Use
PM37397 LOCTITE 592 <sup>1</sup>	Pipe Sealant (General Purpose) with TEFLON® <sup>2</sup>	Seal pipe plug
PM38655 LOCTITE 515 Canada PM38625	Flexible Sealant	Seal transaxle case

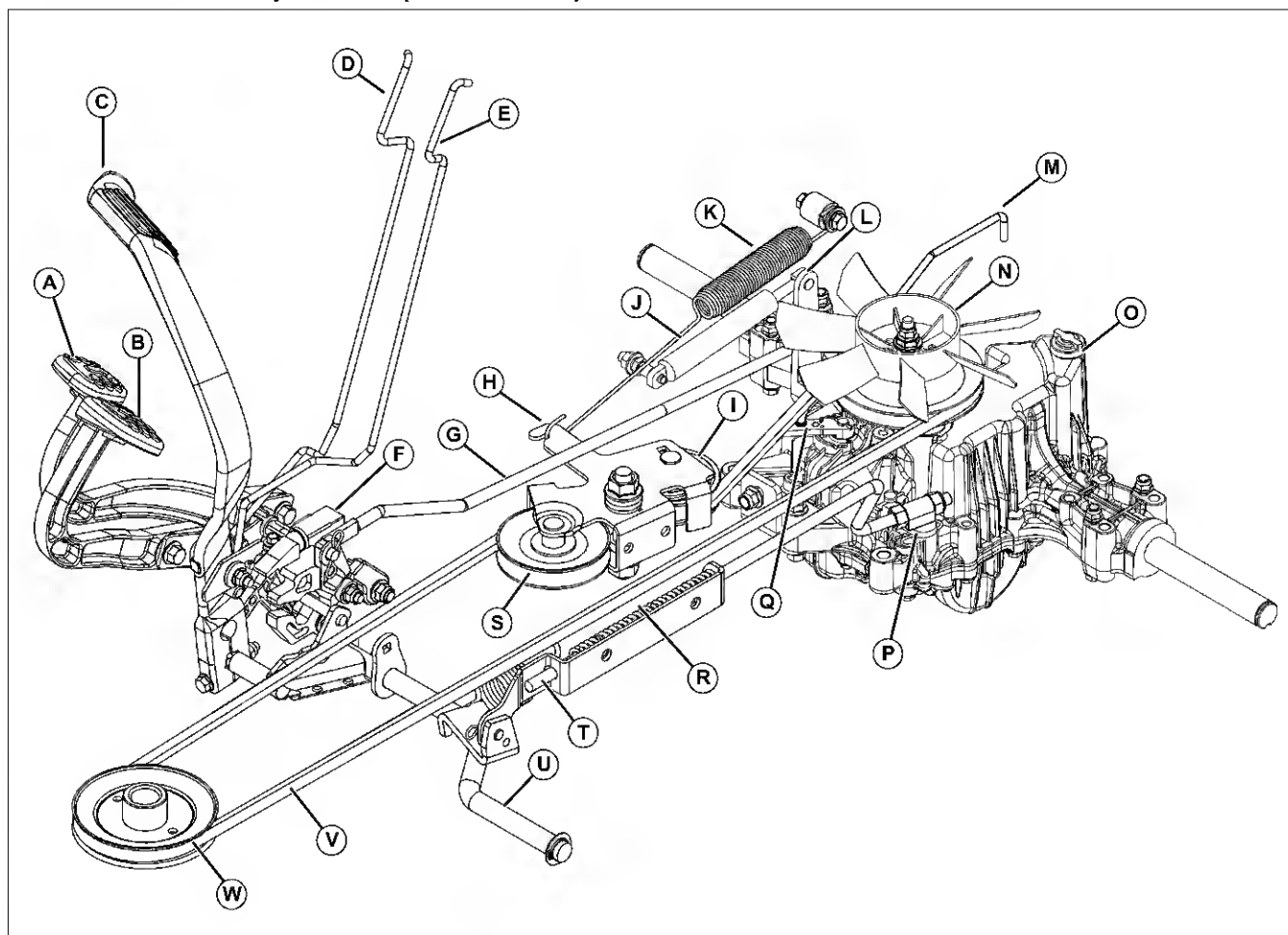
1. LOCTITE® is a registered trademark of the Loctite Corp.

2. TEFLON® is a registered trademark of the DuPont Co.



# POWER TRAIN - HYDROSTATIC COMPONENT LOCATION

## Drive and Brake Components (SN 085001-)



MX39799

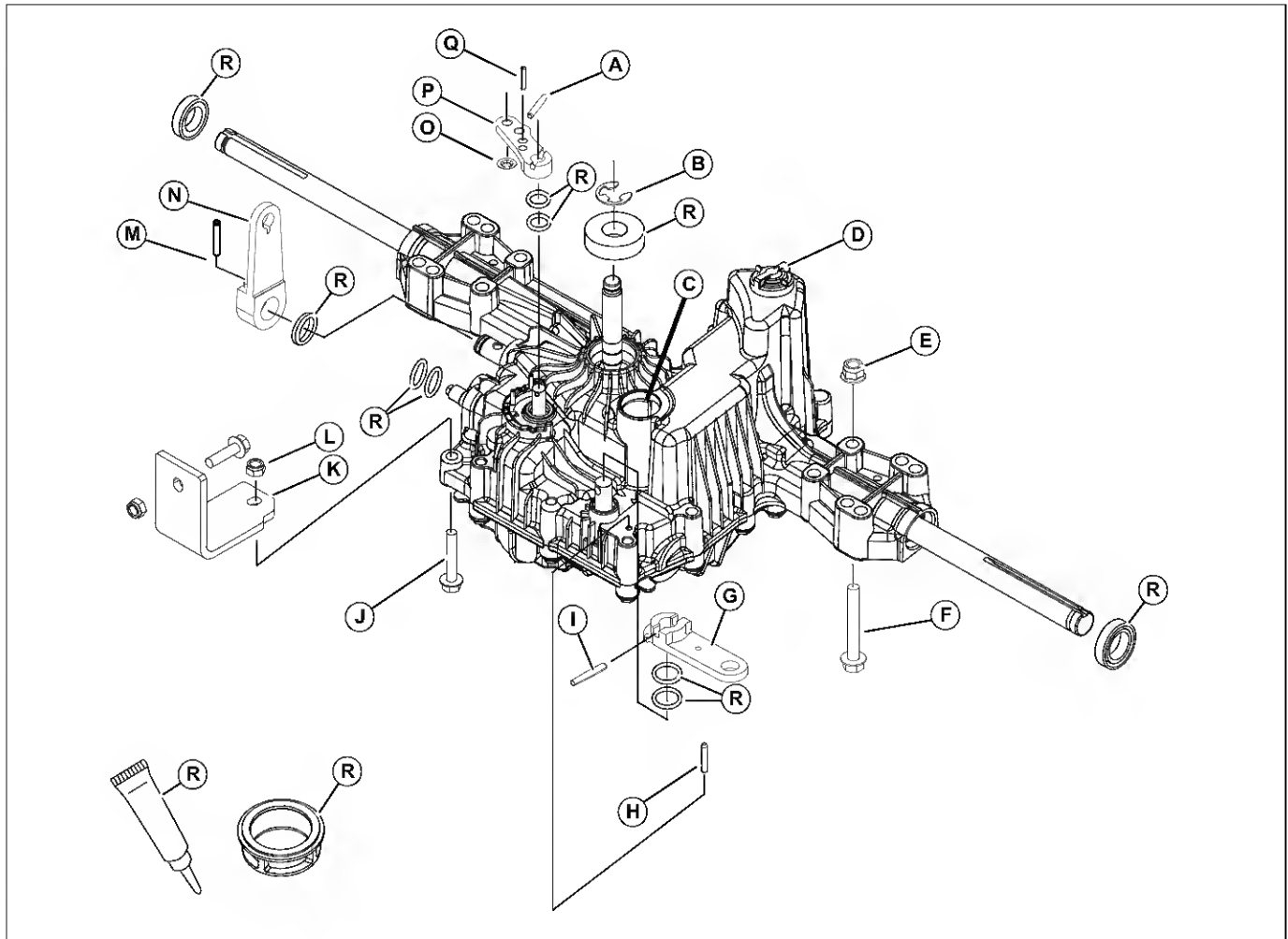
- A- Reverse Pedal
- B- Forward Pedal
- C- Brake Pedal
- D- Cruise Control Latch Rod
- E- Park Brake Latch Rod
- F- Switch
- G- Control Rod
- H- Idler Arm
- I- Idler Pulley
- J- Damper (not used on K46BR transaxle)
- K- Belt Tension Extension Spring
- L- Control Lever
- M- Freewheel Rod
- N- Input Sheave and Fan
- O- Transaxle
- P- Brake Arm
- Q- Bypass Lever
- R- Brake Rod Compression Spring
- S- Idler Pulley
- T- Brake Rod

- U- Brake Shaft Assembly
- V- Drive Belt
- W- Engine Drive Pulley



# POWER TRAIN - HYDROSTATIC COMPONENT LOCATION

## Transaxle Components - K46



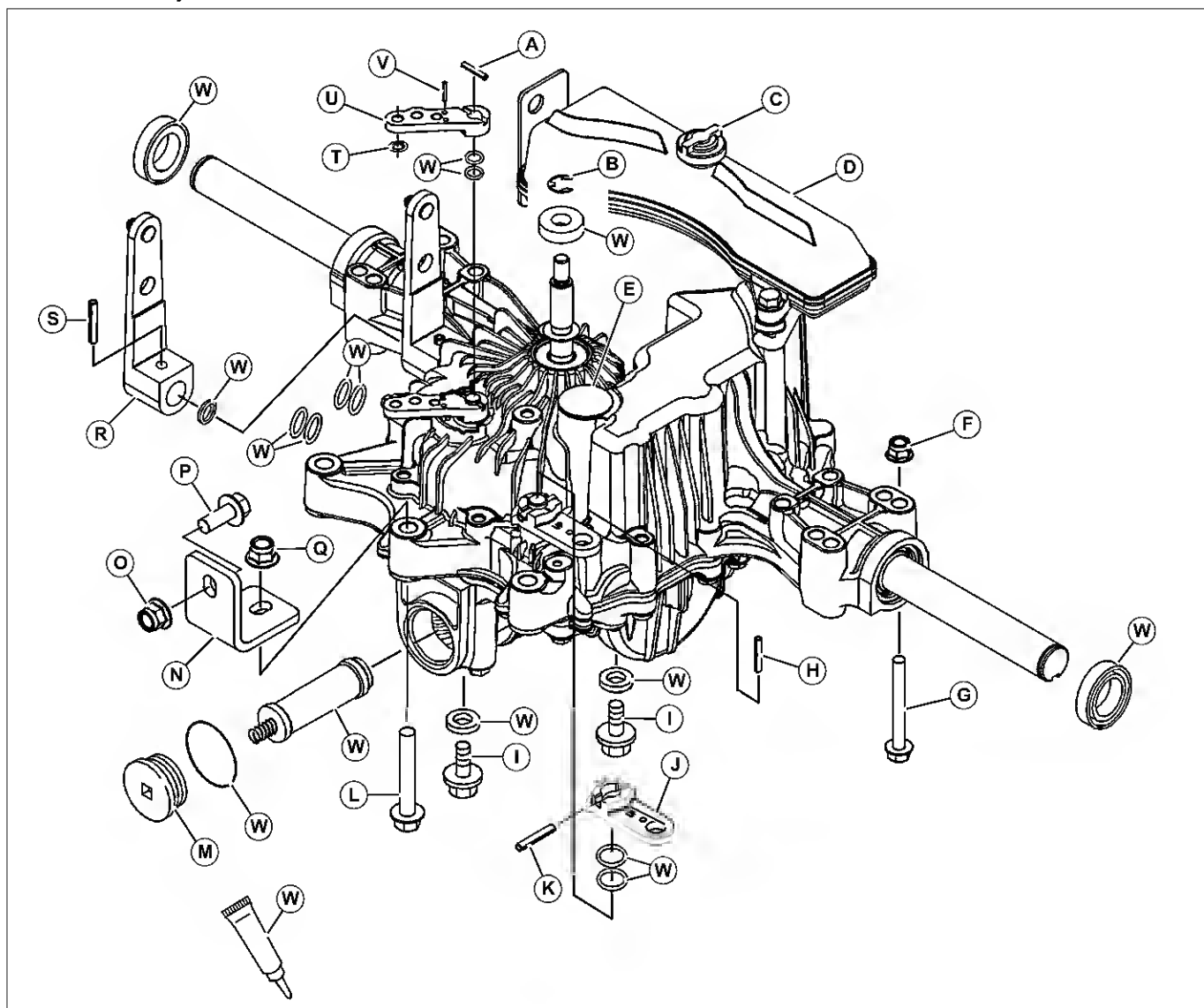
mif

- A- Spring Pin
- B- Snap Ring
- C- Cap
- D- Transaxle Breather Plug (non-serviceable)
- E- Nut (4 used)
- F- Bolt (4 used)
- G- Brake Arm
- H- Spring Pin
- I- Spring Pin
- J- Bolt
- K- Front Support Bracket
- L- Lock Nut
- M- Spring Pin
- N- Control Lever
- O- Push Nut
- P- Bypass Lever
- Q- Spring Pin
- R- Seal Kit Components



# POWER TRAIN - HYDROSTATIC COMPONENT LOCATION

## Transaxle Components - K58H



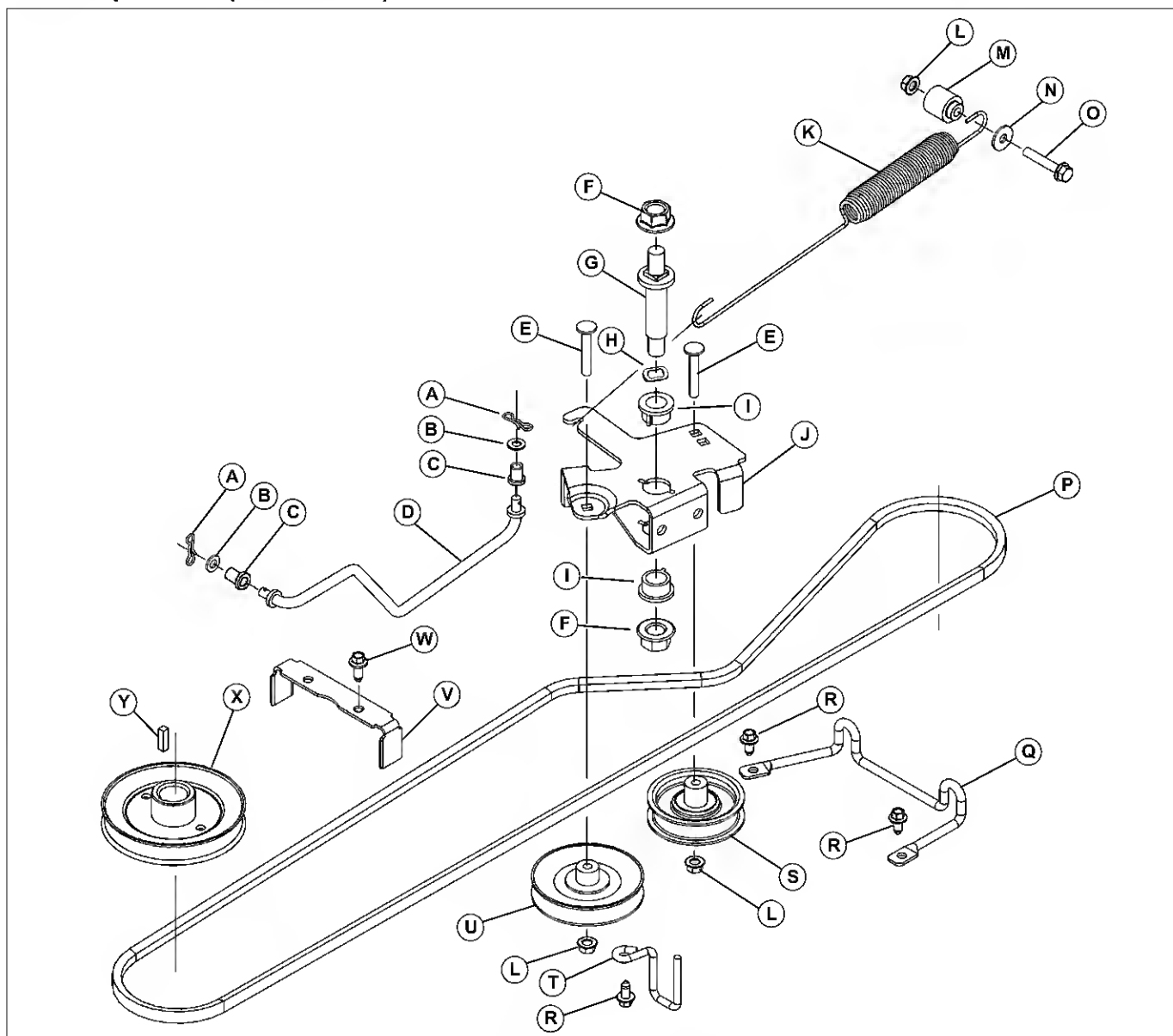
MX40587

- A- Spring Pin
- B- Snap Ring
- C- Transaxle Reservoir Filler Plug
- D- Transaxle Reservoir
- E- Cap
- F- Nut (4 used)
- G- Bolt (4 used)
- H- Spring Pin
- I- Drain Plug (2 used)
- J- Brake Arm
- K- Spring Pin
- L- Bolt
- M- Filter Cap
- N- Front Support Bracket
- O- Lock Nut

- P- Bolt
- Q- Lock Nut
- R- Control Lever
- S- Spring Pin
- T- Push Nut
- U- Bypass Lever
- V- Spring Pin
- W- Seal Kit Components

# POWER TRAIN - HYDROSTATIC COMPONENT LOCATION

## Drive Components (SN -040000)



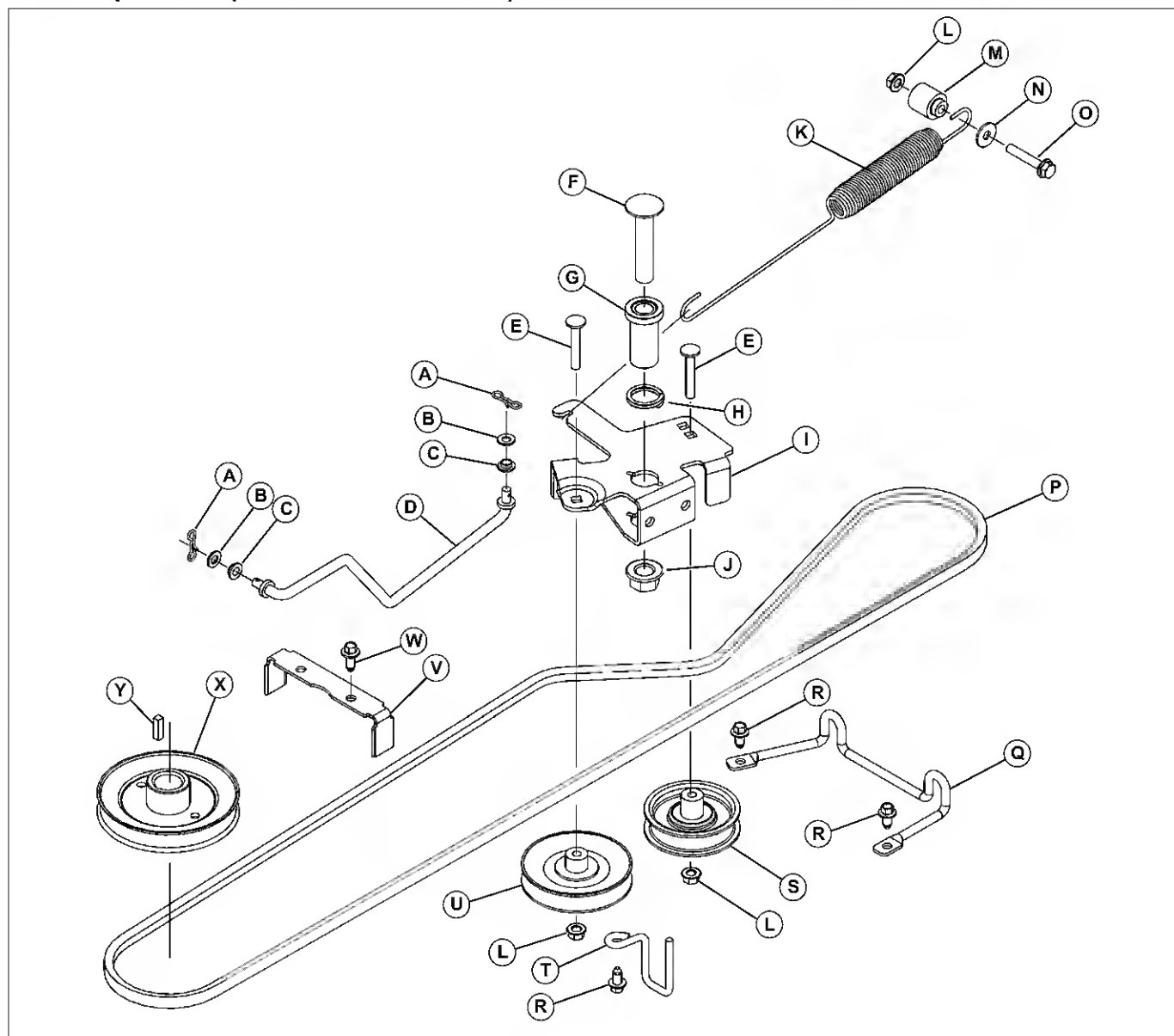
MX37101

- A- Spring Locking Pin
- B- Washer, 8.4 X 16 X 1.6 mm
- C- Bushing (2 used)
- D- Declutch Rod
- E- Bolt, M8 X 50 (2 used)
- F- Flange Nut, M16 (2 used)
- G- Stud
- H- Wave Washer
- I- Bushing (2 used)
- J- Arm
- K- Extension Spring
- L- Flange Nut, M8
- M- Spacer
- N- Washer, 8.4 X 24 X 2 mm

- O- Screw, M8 X 45
- P- V-Belt
- Q- Belt Guide
- R- Screw
- S- Pulley
- T- Belt Guide
- U- Idler
- V- Guide
- W- Screw
- X- Sheave Assembly
- Y- Shaft Key

# POWER TRAIN - HYDROSTATIC COMPONENT LOCATION

Drive Components (SN 040001 to 085000)



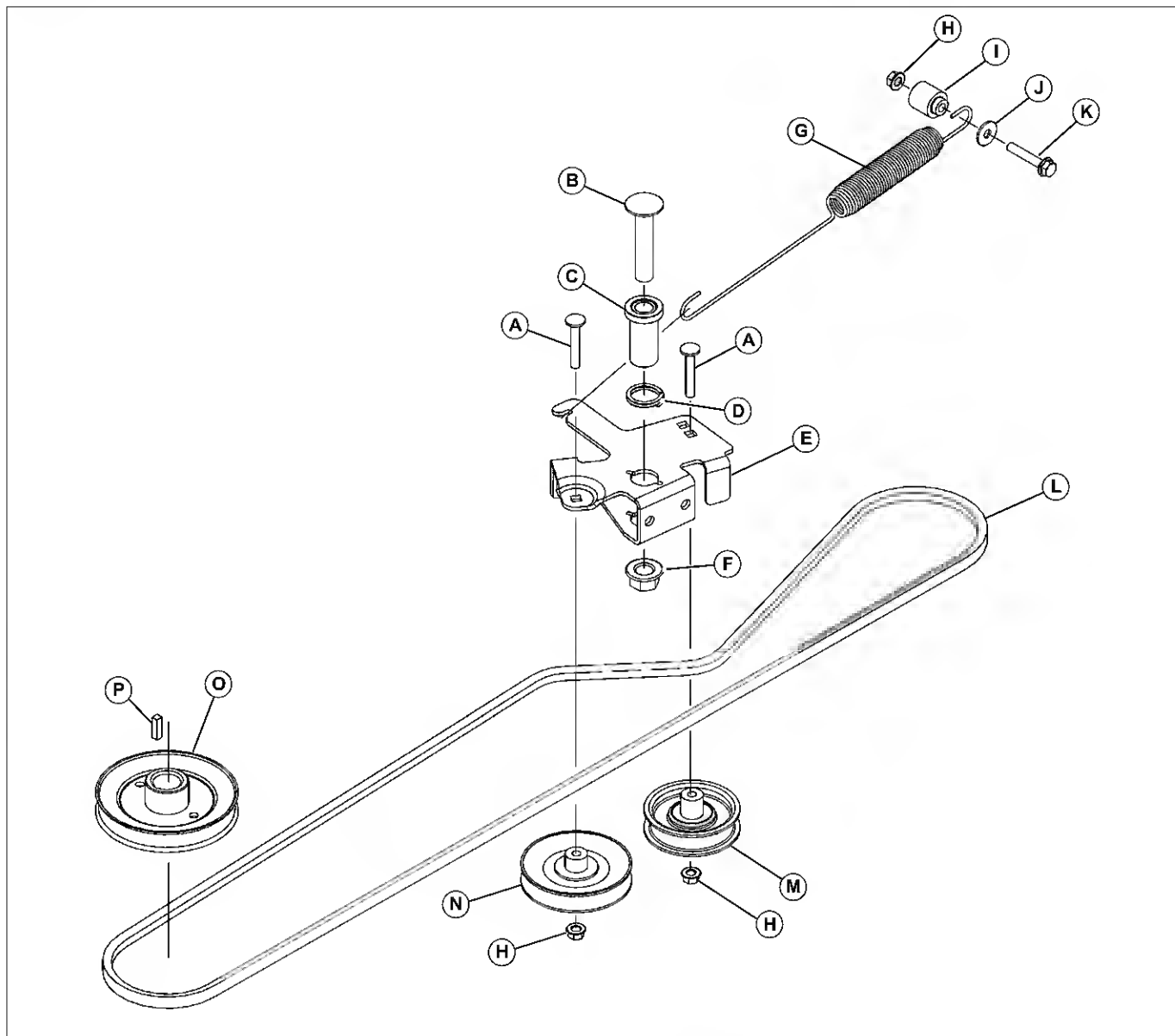
MX38148

- A- Spring Locking Pin
- B- Washer, 8.4 X 16 X 1.6 mm
- C- Bushing (2 used)
- D- Declutch Rod
- E- Bolt, M8 X 50 (2 used)
- F- Bolt, M16 X 80
- G- Bushing
- H- Spring Washer
- I- Arm
- J- Flange Nut, M16
- K- Extension Spring
- L- Flange Nut, M8
- M- Spacer
- N- Washer, 8.4 X 24 X 2 mm

- O- Screw, M8 X 45
- P- V-Belt
- Q- Belt Guide
- R- Screw
- S- Pulley
- T- Belt Guide
- U- Idler
- V- Guide
- W- Screw
- X- Sheave Assembly
- Y- Shaft Key

# POWER TRAIN - HYDROSTATIC COMPONENT LOCATION

## Drive Components (SN 085001-)



MX39798

O- Sheave Assembly

P- Shaft Key

A- Bolt, M8 X 50 (2 used)

B- Bolt, M16 X 80

C- Bushing

D- Spring Washer

E- Arm

F- Flange Nut, M16

G- Extension Spring

H- Flange Nut, M8

I- Spacer

J- Washer, 8.4 X 24 X 2 mm

K- Screw, M8 X 45

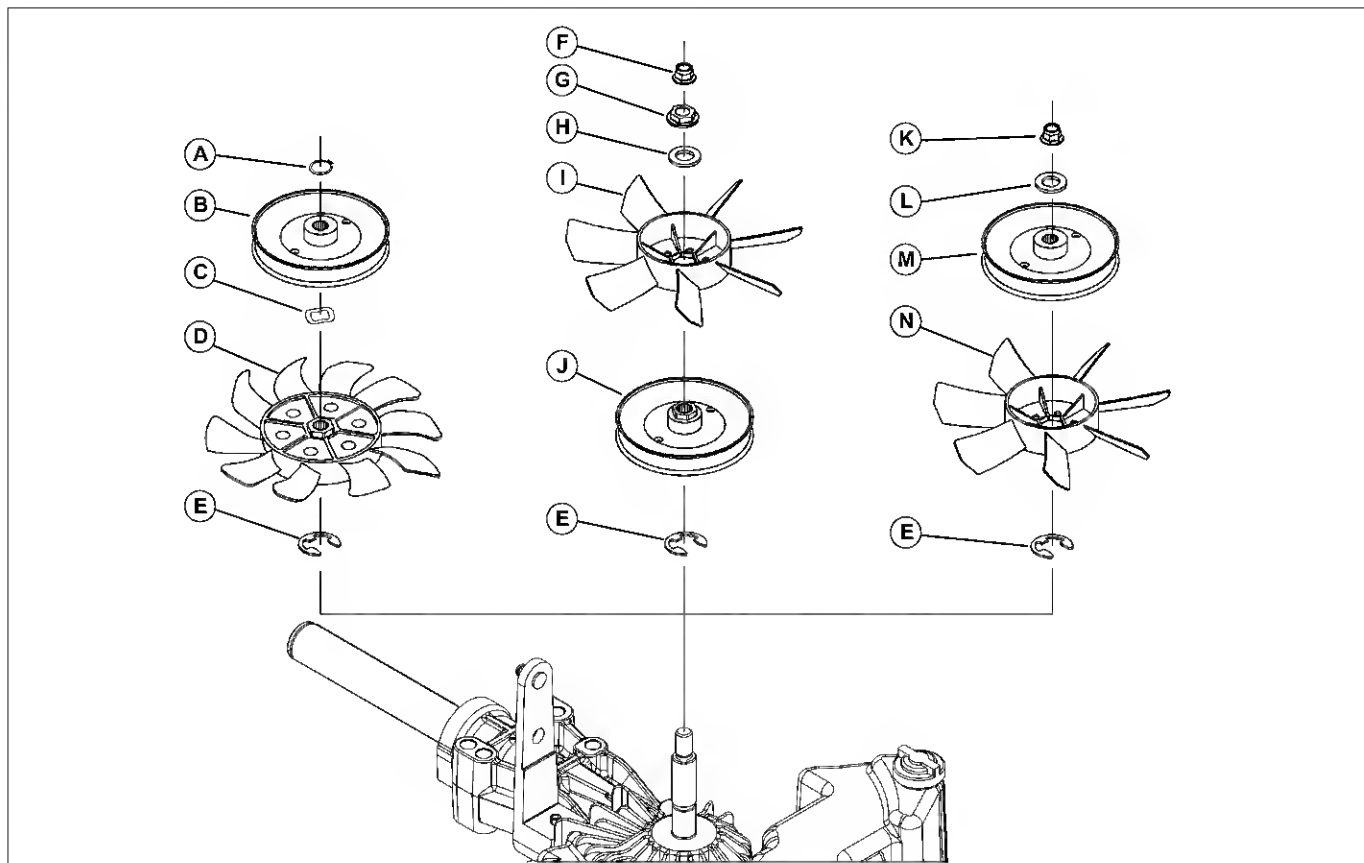
L- V-Belt

M- Pulley

N- Idler

# POWER TRAIN - HYDROSTATIC COMPONENT LOCATION

## Fan Components

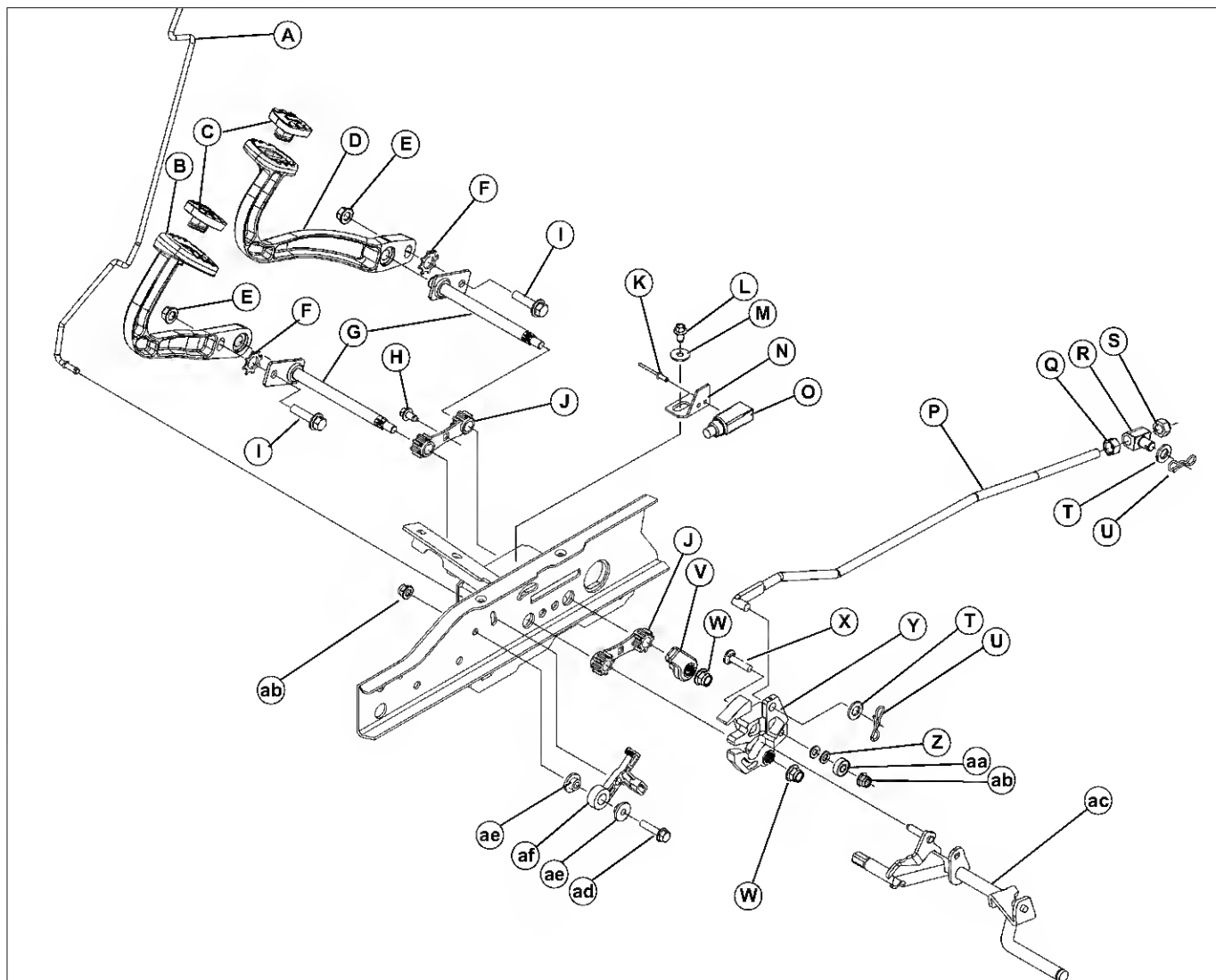


- A- Snap Ring (X300)
- B- Pulley (X300)<sup>1</sup>
- C- Washer (X300)
- D- Fan (X300)
- E- Snap Ring (All)
- F- Lock Nut, M10 (X320, X340, X360)
- G- Bushing (X320, X340, X360)
- H- Washer, 17 X 30 X 3 mm (X320, X340, X360)
- I- Fan (X320, X340, X360)
- J- Pulley (X320, X340, X360)
- K- Lock Nut, M10 (X304, X324)
- L- Washer (X304, X324)
- M- Pulley (X304, X324)
- N- Fan (X304, X324)

1. Pulley diameter change for K46BR transaxles at serial number 040938-.

# POWER TRAIN - HYDROSTATIC COMPONENT LOCATION

## Forward/Reverse Pedals and Linkage (SN -040000)



MX37102

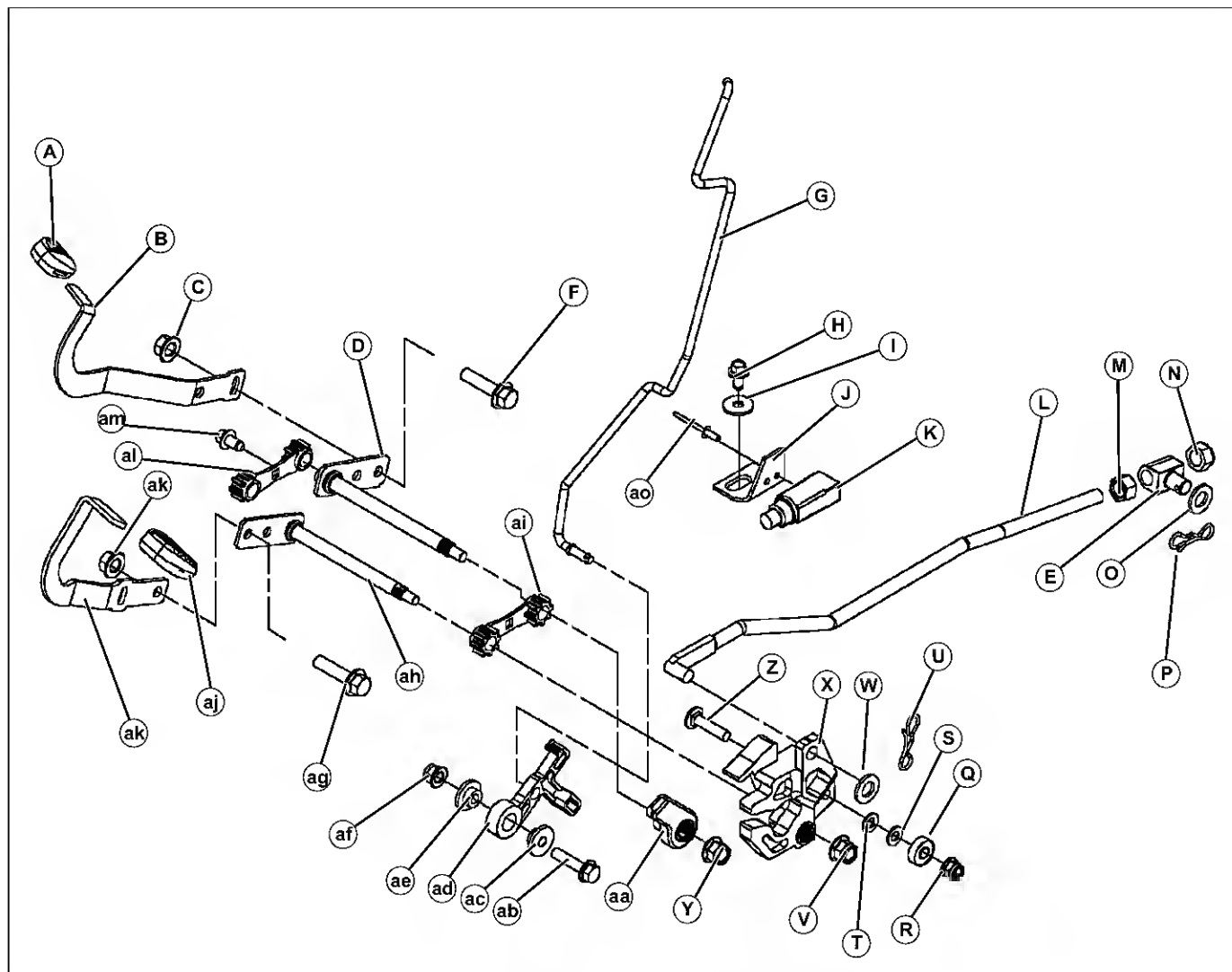
A- Cruise Control Rod  
 B- Forward Pedal  
 C- Pad  
 D- Reverse Pedal  
 E- Flange Nut (M10)  
 F- Serrated Lock Washer  
 G- Pedal Shaft  
 H- Screw  
 I- Screw, M10 X 40  
 J- Bearing with Housing  
 K- Rivet  
 L- Screw  
 M- Washer, 8.4 X 24 X 2 mm  
 N- Bracket  
 O- Switch  
 P- Control Rod

Q- Nut, M12  
 R- Trunnion  
 S- Lock Nut  
 T- Washer, 13 X 24 X 2.5 mm  
 U- Spring Lock Pin  
 V- Reverse Control Arm  
 W- Lock Nut, M10  
 X- Bolt, M8 X 35  
 Y- Forward Control Arm  
 Z- Washer, 8.4 X 16 X 1.6 mm (2 used)  
 AA- Ball Bearing  
 AB- Lock Nut, M8  
 AC- Shaft  
 AD- Screw, M8 X 35  
 AE- Bushing  
 AF- Latch



# POWER TRAIN - HYDROSTATIC COMPONENT LOCATION

## Forward Reverse Pedals and Linkage (SN 040001-)



MX39880

- A- Pad
- B- Reverse Pedal
- C- Flange Nut (M10)
- D- Pedal Shaft
- E- Trunnion
- F- Screw, M10 X 40
- G- Cruise Control Rod
- H- Screw
- I- Washer, 8.4 X 25 X 2mm
- J- Bracket
- K- Reverse Switch
- L- Control Rod
- M- Nut M12
- N- Lock Nut
- O- Washer
- P- Spring Locking Pin

- Q- Ball Bearing
- R- Lock Nut, M8
- S- Washer, 8.4 X 16 X 1.6mm
- T- Washer, 8.4 X 16 X 1.6mm
- U- Spring Locking Pin
- V- Lock Nut, M10
- W- Washer, 13 X 24 X 2.5mm
- X- Forward Control Arm
- Y- Lock Nut, M10
- Z- Bolt, M8 X 35
- AA- Reverse Control Arm
- AB- Screw
- AC- Bushing
- AD- Latch
- AE- Bushing
- AF- Lock Nut, M8
- AG- Screw, M10 X 25

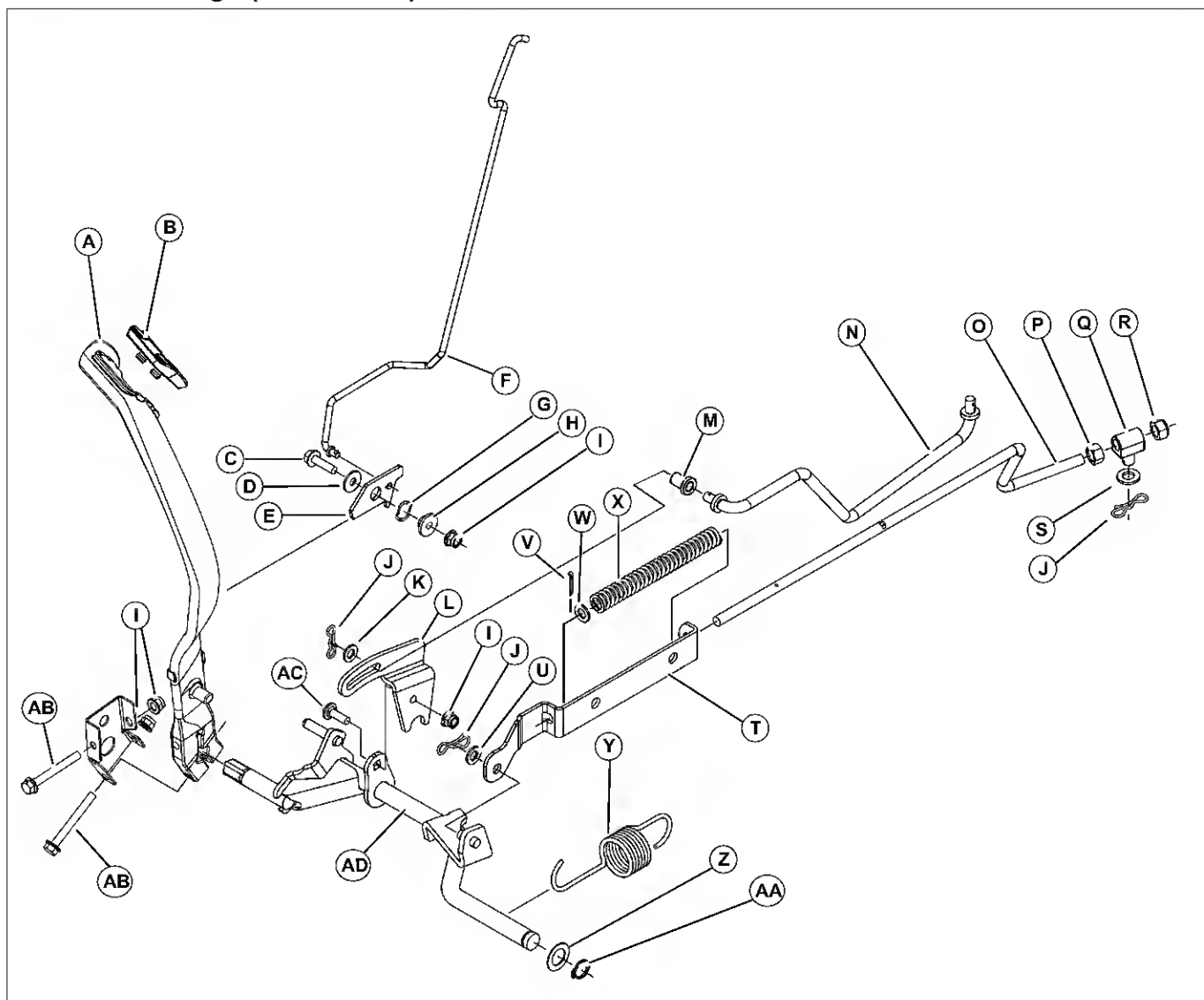
## POWER TRAIN - HYDROSTATIC COMPONENT LOCATION

---

AH- Pedal Shaft  
AI- Bearing with Housing  
AJ- Pad  
AK- Forward Pedal  
AL- Bearing with Housing  
AM- Screw

# POWER TRAIN - HYDROSTATIC COMPONENT LOCATION

## Brakes and Linkage (SN -085000)

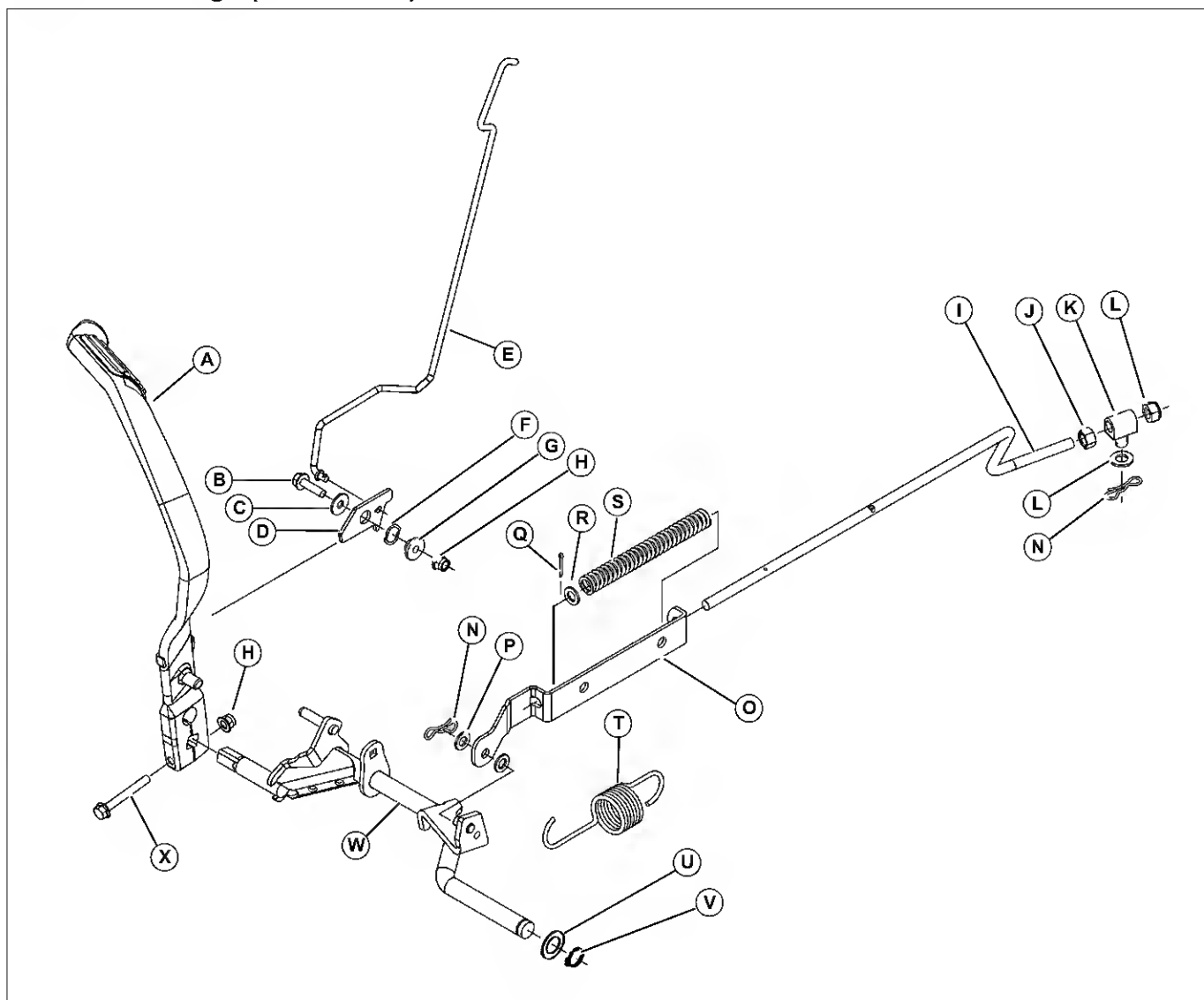


MX37046

- |                             |                                |
|-----------------------------|--------------------------------|
| A- Pedal                    | P- Nut (M12)                   |
| B- Pad                      | Q- Trunnion                    |
| C- Screw (M8 X 30)          | R- Lock Nut                    |
| D- Washer (8.4 X 24 X 2 mm) | S- Washer                      |
| E- Latch                    | T- Strap                       |
| F- Parking Brake Rod        | U- Washer (10.5 X 20 X 2 mm)   |
| G- Washer                   | V- Cotter Pin (3.2 X 20 mm)    |
| H- Bushing                  | W- Washer (11 X 20 X 2 mm)     |
| I- Lock Nut (M8, 4 used)    | X- Compression Spring          |
| J- Spring Lock Pin (3 used) | Y- Extension Spring            |
| K- Washer                   | Z- Washer                      |
| L- Arm                      | AA- Snap Ring                  |
| M- Bushing                  | AB- Screw (M8 X 60 mm, 2 used) |
| N- Declutch Rod             | AC- Bolt                       |
| O- Brake Rod                | AD- Shaft                      |

# POWER TRAIN - HYDROSTATIC COMPONENT LOCATION

## Brakes and Linkage (SN 085001-)



MX39797

- |                                      |                              |
|--------------------------------------|------------------------------|
| A- Pedal                             | P- Washer (10.5 X 20 X 2 mm) |
| B- Screw (M8 X 30)                   | Q- Cotter Pin (3.2 X 20 mm)  |
| C- Washer (8.4 X 24 X 2 mm) (2 used) | R- Washer (11 X 20 X 2 mm)   |
| D- Latch                             | S- Compression Spring        |
| E- Parking Brake Rod                 | T- Extension Spring          |
| F- Washer                            | U- Washer                    |
| G- Bushing                           | V- Snap Ring                 |
| H- Lock Nut (M8, 2 used)             | W- Screw (M8 X 60 mm)        |
| I- Brake Rod                         | X- Shaft                     |
| J- Nut (M12)                         | Y- Bolt                      |
| K- Trunnion                          |                              |
| L- Lock Nut                          |                              |
| M- Washer                            |                              |
| N- Spring Lock Pin (2 used)          |                              |
| O- Strap                             |                              |

# POWER TRAIN - HYDROSTATIC THEORY OF OPERATION

## Theory of Operation

### Traction Drive Belt System

#### Function:

The traction drive belt transfers power from the engine to the input sheave of the hydrostatic transaxle.

#### Theory of Operation:

The traction drive belt is driven by the engine drive sheave. The traction belt transmits engine power to the input sheave of the hydrostatic transaxle.

The traction drive belt is tensioned by two idler sheaves, which are mounted on a spring loaded bracket. The tension spring runs from the idler arm to a frame mounted anchor.

### Transaxle

#### Function:

The function of the transaxle is to transfer power from the traction drive belt system (driven by the engine), to the rear wheels, and allow the operator to select ground speed and direction.

#### Theory of Operation:

The drive belt turns the transaxle input pulley, and transaxle input shaft. This, in turn drives the transaxle hydrostatic pump. When the hydrostatic drive is in neutral, the pump pistons do not move up and down in their bores, therefore, no pressure is built up in the pump. When the operator engages the forward or reverse pedals, the pedal linkage tilts a swash plate inside the transaxle. This causes the pump pistons to travel up and down in their bores. The pump pistons create hydraulic pressure which drives the hydrostatic motor. The motor drives the rear axle and wheels through a reduction gear and differential assembly.

The transaxle provides infinite ground speed selections in forward and reverse.

### Forward and Reverse Pedals

#### Neutral:

When the engine is running, the traction drive belt turns the transaxle input pulley, cooling fan, and input shaft. The input shaft turns the hydrostatic pump input shaft and pump body inside the transaxle. When the forward/reverse pedals are not depressed, the control lever on the transaxle holds the control linkage in the NEUTRAL (centered) position, and the drive axles do not turn.

#### Forward:

When the forward pedal is pressed, the bottom of the

forward pedal bracket is rotated forward, pushing the forward/reverse control rod forward. This moves the control lever on the transaxle forward, turning the control shaft inside the transaxle, and causing the drive axles to turn in the FORWARD direction.

#### Reverse:

When the reverse pedal is depressed, the reverse pedal bracket (seated in the forward pedal bracket) rotates the bottom of the forward pedal bracket rearward and moves the forward/reverse control rod rearward. This moves the control lever on the transaxle rearward, turning the control shaft inside the transaxle, and causing the drive axles to turn in the REVERSE direction.

### Freewheel System

#### Function:



**Caution: Avoid Injury! DO NOT operate freewheel valve with engine running or damage to hydrostatic transmission can occur.**

The freewheel system allows the machine to be pushed forward or reverse with the engine off and the brake released.

#### Theory of Operation:

When the freewheel rod is pulled rearward, the freewheel rod rotates the freewheeling lever. This allows the operator to push the machine in forward or reverse with the engine off and the brake released.

### Brake System

#### Function:

The brake system provides the operator with a method to mechanically stop the movement of the machine. The brake system also provides a parking brake function through the use of a mechanical locking mechanism which, when engaged, holds the brake pedal in the depressed position.

#### Theory of Operation:

When the brake pedal is depressed, the compression spring in the brake assembly is compressed, and the idler arm assembly is rotated, removing tension from the traction drive belt. The brake assembly pulls on a lever on the transaxle. The transaxle brake lever actuates a wet disk brake inside the transaxle.

When the brake pedal is depressed it rotates the brake pedal shaft forward.

On early models there is a belt tension release rod

attached to the shaft. Movement of the shaft is transferred to the rod which engages the end of the slot in the idler arm assembly. Continued movement pulls the left side of the idler arm forward and disengages drive belt tension.

The transaxle brake is an internal wet disk brake. When the brake pedal is pressed or the parking brake is locked, the brake linkage rotates the brake arm.

The brake arm rotates the brake shaft and the brake shaft, acting as a cam, presses the brake shoe against the brake disk.

The brake disk is splined to the hydrostatic motor output shaft.

### Cruise Control

#### Operation:

Use cruise control to maintain travel speed without having to hold the forward travel pedal down.

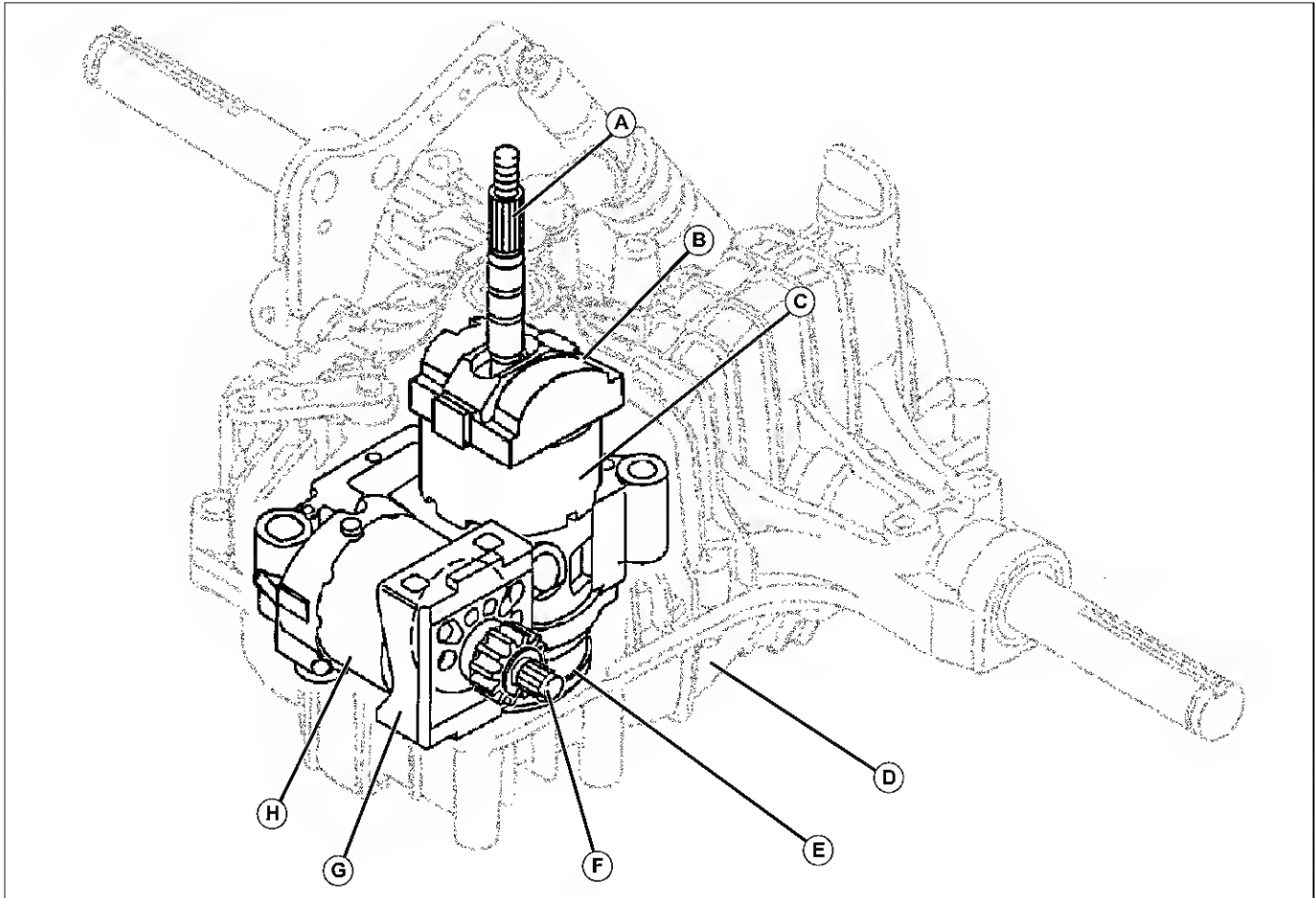
***Note: Cruise control operates only for forward travel.***

Cruise control may be set by lifting the cruise control lever up as the forward pedal is pressed to set the desired ground speed of the machine.

Pressing either the brake or forward pedal will return the cruise control lever to the OFF position.

# POWER TRAIN - HYDROSTATIC THEORY OF OPERATION

## Hydrostatic System Operation



M95065

- A- Pump Input Shaft
- B- Variable Displacement Swash Plate
- C- Pump Rotating Group
- D- Reservoir
- E- Filter
- F- Motor Output Shaft
- G- Fixed Displacement Swash Plate
- H- Motor Rotating Group

### Function:

The hydrostatic transaxle provides a means of transferring power from the input sheave to the axle shafts of the transaxle. It also provides infinitely variable speed control and the capability of forward or reverse directional travel of the machine.

### Theory of Operation:

As the input sheave is rotated by the traction drive belt it rotates the pump input shaft. The pump input shaft is splined to the pump rotating group. The pump rotating group is composed of an axial piston pump and a variable displacement swash plate. The pump rotating group

provides oil under pressure to the motor rotating group. The motor rotating group is composed of an axial piston motor with a fixed position swash plate, and converts hydraulic energy into rotary motion, which is output through the motor output shaft. This rotary motion of the motor output shaft is the beginning of the gear power flow.

### Neutral:

With the transmission in the neutral position, the swash plate is held perpendicular to the piston. Springs in the pump cylinder block force the pump pistons against the swash plate. Since the variable displacement swash plate is perpendicular to the axis of the pistons, there is no reciprocating motion of the pistons in the cylinders, and no oil is displaced. Because there is no demand for oil in the pump, both directional check valves are closed, and the machine remains stationary.

### Forward:

As the direction control arm is moved to the forward position, the variable displacement swash plate is rotated from its neutral position.

Springs inside the pistons force them against the swash plate. As the swash plate angle increases, the pistons are

forced in and out of the pump body as the piston block turns, displacing oil. As the pistons rotate, they follow the angled swash plate, and move outward in their bores, drawing in oil. As the pistons continue to rotate, the swash plate angle forces the pistons back into their bores, and oil is displaced through ports in the center case.

Pressurized oil from the pump forces the forward check valve closed and supplies high pressure oil to the motor rotating group.

The rotating group of the motor presses against a fixed angle swash plate. Oil enters the piston bore through a port in the center case at a point where the piston is compressed in its bore.

As the oil fills the piston bore, the piston is forced out and follows the angle created by fixed swash plate. This causes the motor rotating group to rotate. The motor rotating group is splined to the output shaft. Oil pressure within these components is directly proportional to the load encountered. This is the high pressure side.

The piston continues to be forced out of its bore and follows the fixed angle swash plate until it is no longer aligned with the delivery port of the center case. Since oil is no longer being displaced to the piston, it no longer adds to the rotary motion of the motor. But, since the pistons next in line to it are now filling with oil, the rotary motion is continued.

As the motor continues to rotate, the pistons pass from the high pressure port to the low pressure port and, as the pistons are forced back into their bores by the angle of the swash plate, oil is forced from the piston bores through the center case and back to the inlet port of the pump. This is the low pressure side.

The oil path from the pump to the motor is known as the high pressure side because oil pressure increases, depending on the system load. The oil path from the motor back to the pump is known as the low pressure side. From forward drive to reverse drive these two paths switch, which gives opposite rotation to the motor.

## **Reverse:**

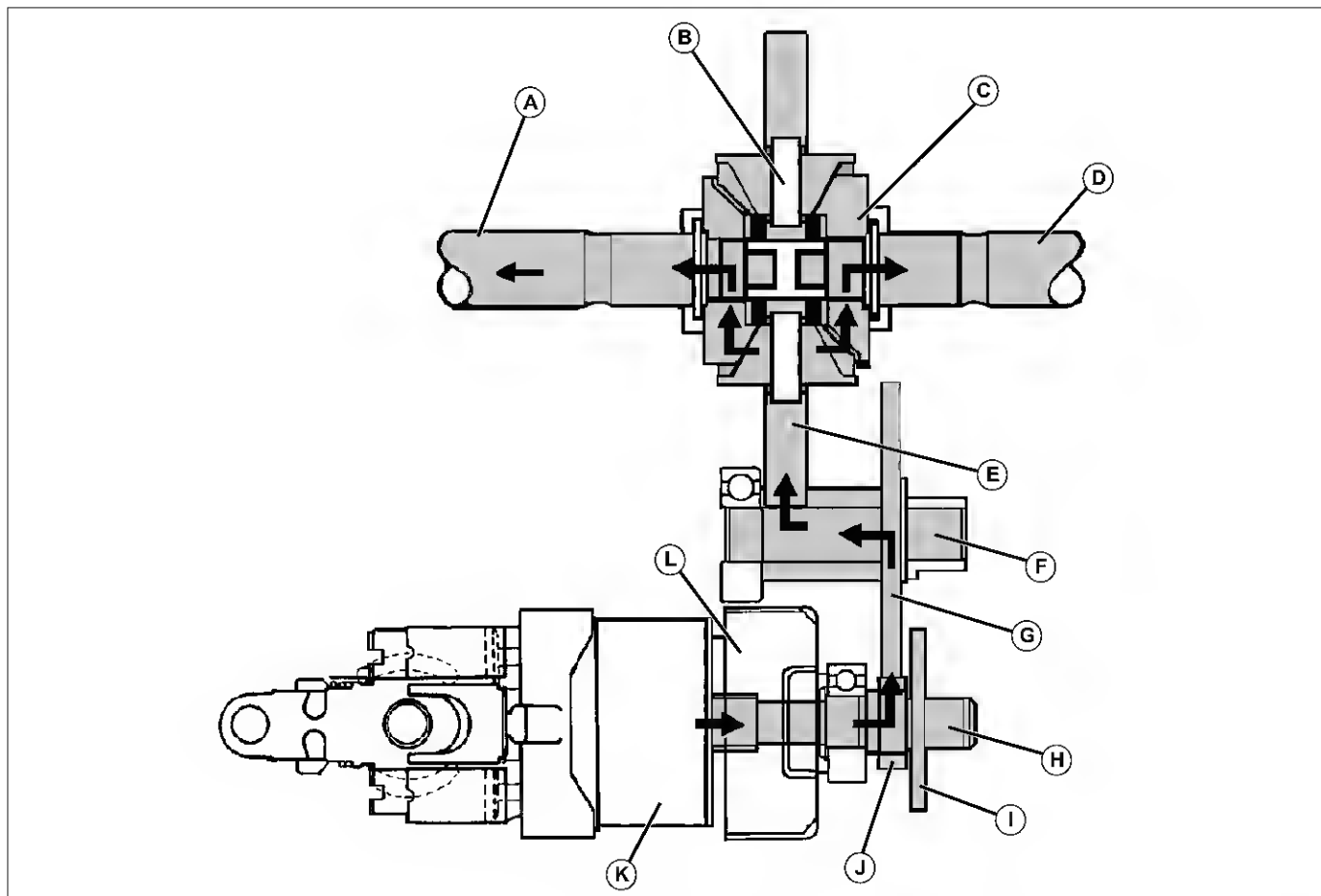
The operation in reverse is the same as in forward. The only difference is that the variable displacement swash plate is rotated in the opposite direction, thus causing oil flow through the center case in the opposite direction. This causes the reverse check valve to close and supply high pressure oil to the opposite side of the motor rotating group. This causes the output shaft to rotate in the opposite direction, and results in reverse travel of the machine.

When in reverse, the reverse check valve is closed due to high pressure oil forcing it against the seat. The forward check valve will open to sump.



# POWER TRAIN - HYDROSTATIC THEORY OF OPERATION

## Gear Power Flow



M95571

- A- Axle Shaft
- B- Differential Pinion Gear
- C- Differential Bevel Gear
- D- Axle Shaft
- E- Differential Ring Gear
- F- Reduction Shaft
- G- Reduction Gear
- H- Output Shaft
- I- Brake Disk
- J- Output Shaft Gear
- K- Hydrostatic Motor
- L- Fixed Swash Plate

the shaft. The output shaft gear meshes with the reduction gear which drives the reduction shaft. The reduction shaft drives the differential ring gear. Power is transferred from the ring gear to the differential pinion shaft and differential pinion gears. The differential bevel gears are splined to the axle shafts and transfer power directly out to the drive wheels.

Splined to the end of the motor output shaft is the brake disc of the brake assembly. The brake is an internal wet disk brake.

When the brake is applied, a lever operated cam presses a brake shoe against the brake disk.

### Function:

The gear components transfer power from the hydrostatic transaxle components of the transaxle, out the drive axles and to the drive wheels. They also provide a means of making turns with differential action for smooth operation.

### Theory of Operation:

The output shaft and output shaft gear are splined to the hydrostatic motor. Power from the motor is transferred to

# POWER TRAIN - HYDROSTATIC DIAGNOSTICS

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## Diagnostics

### Hydrostatic Transmission Check

#### Test Procedure:

##### Test Conditions:

- Machine on level surface.
- Engine OFF.
- Front wheels blocked.
- Rear wheels raised off surface with axle housings on jack stands.

#### Fan

1. Is the fan in good condition and tight?

Yes: Go to next step.

No: Replace defective or worn components.

#### Drive Belt

1. Is the drive belt in good condition and not glazed, split, unraveled, or stretched?

Yes: Go to next step.

No: Replace drive belt.

#### Idle Tensioning Spring

1. Is the tensioning spring installed and not damaged?

Yes: Go to next step.

No: Install spring.

No: Repair or replace.

#### Sheaves and Idlers, Belt Traction Drive System

1. Are drive sheaves and idlers in good condition?

Yes: Go to next step.

No: Repair or replace.

2. Is the belt slipping, squealing, or vibrating excessively?

No: Go to next step.

Yes: Check belt condition. Check condition of idlers and guides. Adjust, repair or replace components as needed.

#### Hydro Housing Exterior

1. Do the cooling fins have accumulated debris?

No: Go to next step.

Yes: Clean the cooling fins.

2. Does the hydro housing exterior have cracks, leaks, or loose hardware?

No: Go to next step.

Yes: Tighten hardware.

Yes: Replace transaxle.

Yes: Replace damaged components.

#### Axles

1. Are the axles straight?

Yes: Go to next step.

No: Replace transaxle as needed.

#### Tires, Wheels, and Axles

1. Are the tire pressures equal?

Yes: Go to next step.

No: Adjust air pressure.

2. Are the driving tires the same size?

Yes: Go to next step.

No: Install same size tires.

3. Are wheels bent or out of round?

No: Go to next step.

Yes: Replace wheels.

4. Are keys, keyways, and E-rings in good shape and seated correctly?

Yes: Go to next step.

No: Repair or replace as needed.

#### Engine Performance

1. Is the engine running smoothly throughout throttle range, and is it being operated at high idle?

Yes: Go to next step.

No: Adjust, tune, or repair engine.

#### Stroking Control Arm: (Lack of Forward or Reverse Speed)

1. Is there lost motion between the control arm and shaft?

Yes: Check roll pin for damage or shearing. Replace as necessary.

No: Go to next step.

2. Does the linkage stroke control move until it reaches the stop inside the transaxle (Forward) and 2/3 stroke in reverse?

Yes: Checks complete.

No: Install adjustable motion control rod kit.

# POWER TRAIN - HYDROSTATIC DIAGNOSTICS

## Hydrostatic Transmission Diagnosis

### Symptom: Transmission Has Low Power When Hot, Especially In Reverse

Problem	Cause - Solution
1. Does the travel pedal go all the way to the foot deck in forward?	a. Yes - Go to next step. b. No - Check for bent or damaged linkage. Repair or replace as necessary. c. No - Check for damaged or sheared roll pin at control arm to transaxle control shaft junction. Replace as necessary.
2. Does the machine have full forward power when the pedal is pressed to the floor?	a. Yes - Go to next step. b. No - Is the freewheel rod pushed in fully? c. No - Check traction belt and traction drive belt tensioner. d. No - Check neutral creep adjustment. See "Neutral Creep Adjustment" on page 392.
3. Does the pedal move down approximately 2/3 of the way down in reverse, but still has low power with the engine at high idle and the transmission oil hot?	a. Yes - Check for lost motion of control lever on transmission due to wear of linkage parts. Repair as needed. b. No - Is the oil level correct (20-25 mm (0.5-0.75 in.)) below the top of the transmission case) and is the oil viscosity correct? Note: Transmission has to be removed to check oil level. c. No - Replace transmission.

### Will Not Move Forward or Reverse

#### Test Conditions:

**Note:** Some steps require removal of transaxle from machine.

- Machine parked on level surface.
- Key switch off.
- Park brake unlocked.
- Transaxle in neutral.

### Symptom: Machine Will Not Move Forward or Reverse

Problem	Cause - Solution
1. Hydrostatic transaxle oil to full mark?	a. Yes - Go to next step. b. No - Fill reservoir to correct level with specified oil.
2. Is the park brake locked?	a. Yes - Unlock park brake. b. No - Go to next step.
3. Is the freewheeling lever disengaged?	a. Yes - Go to next step. b. No - Disengage freewheeling lever.
4. Is the traction belt worn, frayed, glazed or stretched?	a. Yes - Replace traction belt. See "Traction Drive Belt Removal and Installation (SN -085000)" on page 395 or "Traction Drive Belt Removal and Installation (SN 085001-)" on page 396. b. No - Go to next step.
5. Is the traction belt properly tensioned?	a. Yes - Go to next step. b. No - Check belt tensioning spring and belt. Replace worn/damaged/missing parts.
6. Is the brake linkage properly adjusted?	a. Yes - Go to next step. b. No - Adjust brake linkage.
7. Are the brake rod and lever damaged or binding?	a. Yes - Eliminate binding, replace damaged components. b. No - Go to next step.
8. Does the forward/reverse pedal linkage move freely?	a. Yes - Go to next step. b. No - Eliminate binding, replace faulty or damaged components.
9. Are the control arm and spring pin intact and present?	a. Yes - Go to next step. b. No - Replace control arm and/or spring pin.
10. (SN -040000) Is the shock absorber binding or damaged?	a. Yes - Replace shock absorber. b. No - Go to next step.
11. Are the engine and transaxle drive sheaves intact, and are the keys or keyways damaged?	a. Yes - Replace sheaves or keys. b. No - Go to next step.
12. Idler arm assembly pivots freely, no wear in bearing?	a. Yes - Go to next step. b. No - Lubricate and/or replace assembly.

# POWER TRAIN - HYDROSTATIC DIAGNOSTICS

## Symptom: Machine Will Not Move Forward or Reverse

Problem	Cause - Solution
---------	------------------

- |   |   |
|---|---|
| 13. Belt idler assembly tension spring maintains tension on belt? | a. Yes - Go to next step.<br>b. No - Replace tensioning spring.                           |
| 14. Freewheel linkage components move freely and are not damaged? | a. Yes - Go to next step.<br>b. No - Eliminate binding and/or replace damaged components. |

## Machine Moves In One Direction Only

### Test Conditions:

**Note:** Some steps requires removal of transaxle from machine.

- Machine parked on level surface.
- Key switch off.
- Park brake unlocked.
- Transaxle in neutral.

## Symptom: Machine Moves In One Direction Only

Problem	Cause - Solution
1. Is the forward/reverse pedal linkage properly adjusted?	a. Yes - Go to next step. b. No - Adjust linkage.
2. Does the forward/reverse pedal linkage move freely?	a. Yes - Go to next step. b. No - Eliminate binding, replace faulty or damaged components.
3. (SN -040000) Is the shock absorber binding or damaged?	a. Yes - Replace shock absorber. b. No - Go to next step.
4. Is the control arm free of damage?	a. Yes - Go to next step. b. No - Replace control arm and/or spring pin.

## Machine Does Not Achieve Full Speed

### Test Conditions:

**Note:** Some steps require removal of transaxle from machine.

- Machine parked on level surface.
- Key switch off.
- Park brake unlocked.
- Transaxle in neutral.

## Symptom: Machine Does Not Achieve Full Speed

Problem	Cause - Solution
1. Transaxle free of debris?	a. Yes - Go to next step. b. No - Remove debris from transaxle.
2. Cooling fan not damaged.	a. Yes - Go to next step. b. No - Replace cooling fan.
3. Hydrostatic reservoir oil at full mark, at operating temperature, clean and not foamy?	a. Yes - Go to next step. b. No - Fill reservoir to correct level. Drain transaxle and fill to correct level with specified oil. Bleed air from system.
4. Is the traction belt worn, frayed, glazed or stretched?	a. Yes - Replace traction belt. See "Traction Drive Belt Removal and Installation (SN -085000)" on page 395 or "Traction Drive Belt Removal and Installation (SN 085001-)" on page 396. b. No - Go to next step.
5. Is the traction belt properly tensioned?	a. Yes - Go to next step. b. No - Check belt tensioner and spring for binding or damage. Repair as needed
6. Is the park brake locked?	a. Yes - Unlock park brake. b. No - Go to next step.
7. Swash plate and control lever not bent or worn?	a. Yes - Go to next step. b. No - Replace damaged or worn components.
8. Brake linkage adjusted properly, brake rod and lever not damaged or binding?	a. Yes - Go to next step. b. No - Adjust brake linkage.

# POWER TRAIN - HYDROSTATIC DIAGNOSTICS

## Symptom: Machine Does Not Achieve Full Speed

Problem	Cause - Solution
9. Does the forward/reverse pedal linkage move freely?	a. Yes - Go to next step. b. No - Eliminate binding, replace faulty or damaged components.
10. (SN -040000) Is the shock absorber binding or damaged?	a. Yes - Replace shock absorber. b. No - Go to next step.
11. Freewheel linkage and lever move freely and are not damaged?	a. Yes - Go to next step. b. No - Eliminate binding and/or replace damaged components.

## Noisy Operation

### Test Conditions:

**Note: Some steps requires removal of transaxle from machine.**

- Machine parked on level surface.
- Key switch off.
- Park brake unlocked.
- Transaxle in neutral.

## Symptom: Noisy Operation

Problem	Cause - Solution
1. Hydrostatic oil at full mark, at operating temperature, clean and not foamy?	a. Yes - Go to next step. b. No - Check oil level - (20-25 mm (0.5-0.75 in.)) below the top of the transmission case) and for correct oil viscosity. Note: Transmission has to be removed to check oil level. Drain transaxle and fill to correct level with specified oil. Bleed air from system.
2. Park brake unlocked?	a. Yes - Go to next step. b. No - Unlock park brake.
3. Brake linkage adjusted properly, brake rod and lever not damaged or binding?	a. Yes - Go to next step. b. No - Adjust brake linkage. Eliminate binding and/or replace damaged components.
4. Freewheel linkage and lever move freely and are not damaged?	a. Yes - Go to next step. b. No - Eliminate binding and/or replace damaged components.

## Machine Creeps

### Test Conditions:

**Note: Some steps requires removal of transaxle from machine.**

- Machine parked on level surface.
- Key switch off.
- Park brake unlocked.
- Transaxle in neutral.

## Symptom: Machine Creeps

Problem	Cause - Solution
1. Is the forward/reverse pedal linkage properly adjusted?	a. Yes - Go to next step. b. No - Adjust linkage.
2. Does the forward/reverse pedal linkage move freely?	a. Yes - Go to next step. b. No - Eliminate binding, replace faulty or damaged components.
3. Are the control arm and spring pin intact and present?	a. Yes - Go to next step. b. No - Replace control arm and/or spring pin.
4. (SN -040000) Is the shock absorber binding or damaged?	a. Yes - Replace shock absorber. b. No - Go to next step.
5. Is the neutral eccentric properly adjusted for no wheel movement at fast idle?	a. Yes - Go to next step. b. No - Adjust neutral eccentric. See "Neutral Creep Adjustment" on page 392.
6. Neutral return spring returns swash plate to neutral when forward/reverse pedals are released?	a. No - Replace damaged or worn components.

# POWER TRAIN - HYDROSTATIC DIAGNOSTICS

## Erratic Speed

### Test Conditions:

**Note:** Some steps requires removal of transaxle from machine.

- Machine parked on level surface.
- Key switch off.
- Park brake unlocked.
- Transaxle in neutral.

### Symptom: Erratic Speed

Problem	Cause - Solution
1. Is the traction belt worn, frayed, glazed or stretched?	a. Yes - Replace traction belt. See "Traction Drive Belt Removal and Installation (SN -085000)" on page 395 or "Traction Drive Belt Removal and Installation (SN 085001-)" on page 396. b. No - Go to next step.
2. Is the traction belt properly tensioned?	a. Yes - Go to next step. b. No - Check belt tensioner and spring for binding or damage. Repair as needed
3. Brake linkage adjusted properly, brake rod and lever not damaged or binding?	a. Yes - Go to next step. b. No - Adjust brake linkage. Eliminate binding and/or replace damaged components.

## Brake Switch Will Not Engage

### Test Conditions:

- Machine parked on level surface.
- Key switch off.
- Park brake unlocked.
- Transaxle in neutral.

### Symptom: Brake Switch Will Not Engage

Problem	Cause - Solution
1. Is transaxle free of debris?	a. Yes - Go to next step. b. No - Remove debris from transaxle.

### Symptom: Brake Switch Will Not Engage

Problem	Cause - Solution
2. Is the forward/reverse pedal linkage properly adjusted?	a. Yes - Go to next step. b. No - Adjust linkage.
3. Does the forward/reverse pedal linkage move freely?	a. Yes - Go to next step. b. No - Eliminate binding, replace faulty or damaged components.
4. Brake linkage adjusted properly, brake rod and lever not damaged or binding?	a. Yes - Go to next step. b. No - Adjust brake linkage. Eliminate binding and/or replace damaged components.
5. Does the brake switch have continuity with park brake locked?	a. Yes - Go to next step. b. No - Test brake switch. See "Brake Switch Test" on page 356 in Electrical section. Replace switch as needed.
6. (SN -040000) Is the shock absorber binding or damaged?	a. Yes - Replace shock absorber.

## Park Brake Does Not Hold Machine

### Test Conditions:

**Note:** Some steps requires removal of transaxle from machine.

- Machine parked on level surface.
- Key switch off.
- Park brake unlocked.
- Transaxle in neutral.

### Symptom: Park Brake Does Not Hold Machine

Problem	Cause - Solution
1. Brake pedal and linkage are not damaged, worn, or binding?	a. Yes - Go to next step. b. No - Eliminate binding and/or replace damaged components.
2. Park brake lever and linkage are not damaged, worn, or binding?	a. Yes - Go to next step. b. No - Eliminate binding and/or replace damaged components.
3. Brake disk, shoe and brake assembly are not damaged, worn, or binding?	a. Yes - Go to next step. b. No - Eliminate binding and/or replace damaged components.

# POWER TRAIN - HYDROSTATIC TESTS AND ADJUSTMENTS

## Transaxle Whines When Brake Is Used

### Test Conditions:

- Machine on level surface.
- Key switch in run position.
- Park brake locked.
- Transaxle in neutral.

### Symptom: Transaxle Whines When Brake Is Used

#### Problem

#### Cause - Solution

- |  |   |
|--|---|
| 1. Transaxle whines when brake is used, or park brake is locked? | a. Yes - Adjust neutral return arm bearing. |
|--|---|

## Tests and Adjustments

### Traction Drive System Test

#### Reason:

To ensure forward drive, brake linkages and belt drive system maintain traction up a 17° slope.

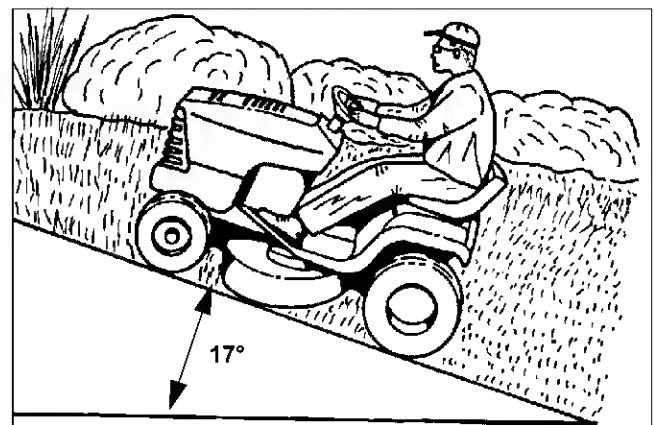
To ensure that transport (freewheeling) valve assembly and linkage allow machine to be pushed when engaged (rod pulled rearward) and to drive machine when disengaged. Also to ensure machine returns to NEUTRAL, engages the brake, stops machine within specification, and holds machine stationary in PARK position on a 17° slope or less.

#### Test Drive:



**Caution: Avoid Injury! DO NOT engage FORWARD foot pedal too aggressively during the 17° slope test drive. Machine may tip over backwards. Install the mower deck before performing the 17° slope test.**

1. Attach mower deck to machine.
2. Carefully test drive machine to see if traction drive system pulls machine steadily up a 17° slope.
3. If machine fails traction test, the drive belt may be worn, stretched, glazed or unraveling. Replace belt or other worn parts if above conditions exist.



M89154

4. Drive or push machine onto a 17° slope, depress the brake pedal and lock it in the PARK position.
5. FORWARD and REVERSE pedals must return to NEUTRAL. Park brake must hold machine in a stationary position on slope and machine must not creep downward once park brake is locked into position.
6. Drive machine on dry pavement in a safe, open and level area at fast idle in the forward direction. Apply "panic stop" force - machine must stop within 1.68 M (5.5 ft) and

# POWER TRAIN - HYDROSTATIC TESTS AND ADJUSTMENTS

both wheels should "lock-up", leaving skid marks on pavement.

7. If any test fails, the brake linkage or the motion control rod (if adjustable) must be adjusted or components replaced.

## Neutral Creep Adjustment

### Reason:

If the machine creeps with the forward/reverse pedals in NEUTRAL, parking brake released and the engine running, the neutral eccentric must be adjusted.

### Procedure:

1. Park machine on level surface.
2. Turn key switch to STOP.
3. Move FORWARD/REVERSE pedals to NEUTRAL position. Release parking brake.



**Caution: Avoid Injury!** Keep hands away from transaxle cooling fan and wheels during procedure to avoid injury.

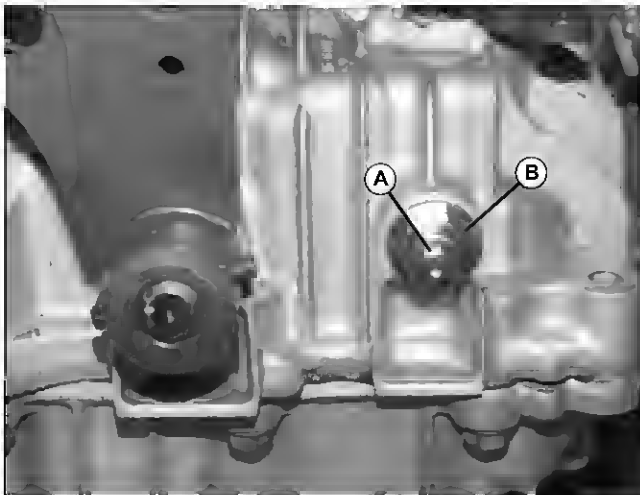
4. Lift rear of machine until wheels are off the ground. Support on suitable stands.

**Note: The eccentric shaft is located on the right side of the transaxle above and in front of the axle.**

5. Place blocks in front of and behind front wheels.

**Note: Engine will not start with seat switch disconnected. Use a jumper wire to bypass switch.**

6. Start and run engine at FAST idle.



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7. Loosen lock nut (B) on eccentric (A). Rotate eccentric to eliminate neutral creep.

8. Hold eccentric in position with a wrench. Tighten lock nut.

9. Remove seat switch jumper wire and reconnect seat switch.

## Transport (Freewheel) Test

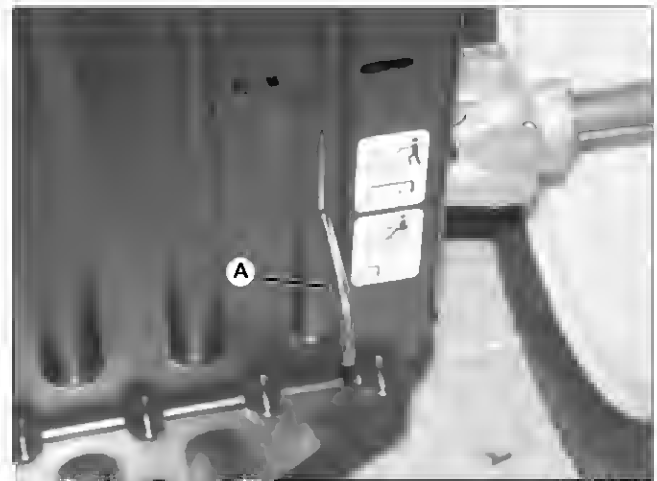
### Reason:

To ensure that machine can be moved manually without damage to transaxle when freewheel rod is pulled.

### Procedure:

**Important: Avoid Damage! DO NOT operate freewheel valve with engine running or damage to hydrostatic transmission can occur.**

1. Release park brake.



MX36171

2. With engine OFF and forward/reverse pedals disengaged, pull freewheel rod (A) out to the freewheel position.
3. Push machine forward at least 3.0 m (10 ft). Machine should push easily the entire distance.
4. Push machine backwards the same distance - machine should push easily the entire distance.
5. If machine pushes hard in either direction, internal components could be damaged or worn. Inspect freewheeling linkage or replace transaxle.

**Important: Avoid Damage! After using transport (freewheel), be sure to push engagement rod completely back into machine. If not completely engaged, the transaxle will not operate properly, will be excessively noisy, and could be damaged.**



# POWER TRAIN - HYDROSTATIC TESTS AND ADJUSTMENTS

## Transaxle Bleeding (Except X360)

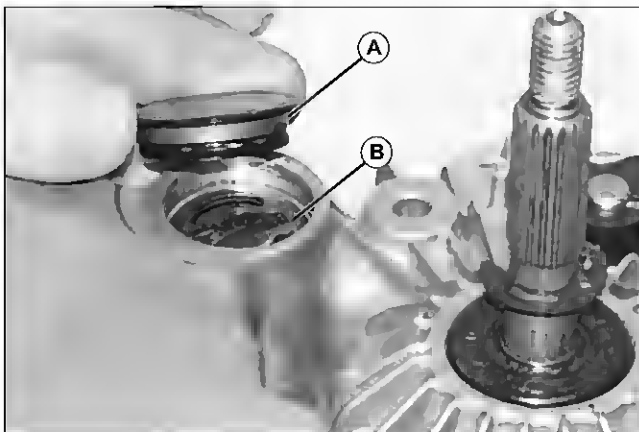
### Reason:

This procedure is performed to eliminate air from the hydrostatic transaxle after repair or leakage of the transaxle.

### Checking and Filling Reservoir Level Procedure:

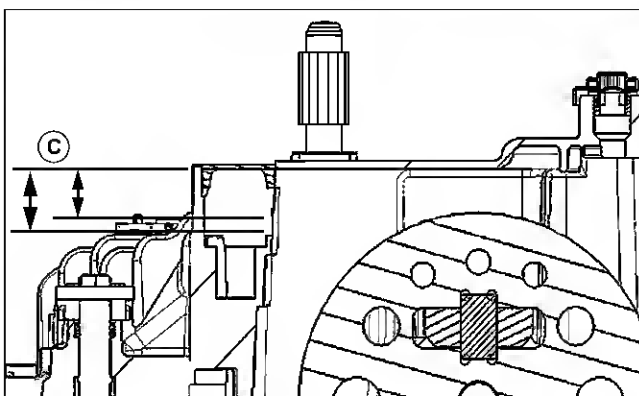
**Note:** The transaxle is a sealed system. Perform this procedure only if the transaxle was disassembled for service or there is a problem with the unit.

1. Park machine safely on a level surface with park brake locked.
2. Remove steering shaft and pedestal.
3. Remove fenderdeck. See "Fenderdeck Removal and Installation" on page 566 in the Miscellaneous section.
4. Remove fuel tank. See "Fuel Tank Removal and Installation" on page 567 in the Miscellaneous section.
5. Remove transaxle cooling fan.



MX37632

6. Carefully clean around magnet cap to prevent contamination of oil. Remove cap (A) and keeper ring (B) and disc magnet.



MX37724

K58 Shown

7. Check that oil level is within specification range.
8. Replace cap and install all removed components.

### Oil Level Specifications:

**Oil Level Below Opening (C) . . 20 - 25 mm (0.8 - 1.0 in.)**

### Bleeding Procedure:

1. Raise rear wheels off the ground. Support rear axle housing with jack stands.
2. Place blocks in front of and behind front wheels.
3. Start and run engine at slow idle.



**Caution: Avoid Injury! Moving parts. Keep loose articles of clothing, hands and feet away from wheels during procedure to reduce the risk of personal injury.**

4. While alternately depressing the FORWARD and REVERSE pedals, engage and disengage the freewheel valve lever. Continue this procedure until the rear wheels start to rotate. This step may take 5 to 10 minutes.
5. Turn off engine.
6. Raise rear of machine, remove stands. Lower the machine to the ground.
7. Remove blocks in front of and behind front wheels.
8. With engine off and control pedals in NEUTRAL, push the machine forward and then rearward to turn the motor rotating group.
9. Start and run the engine at fast idle.
10. Quickly depress and release the forward and reverse pedals until the machine moves without hesitation.
11. Park machine safely. See "Parking Safely" in the Safety section.
12. The following oil is recommended:

- SAE 10W-30 Oil

### Alternative oils:

- TURF-GARD® 10W-30.
- SAE 5W-30

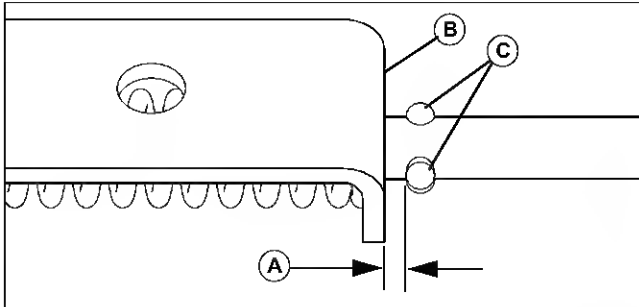
### Results:

- Machine moves without hesitation when forward or reverse pedals are depressed.

# POWER TRAIN - HYDROSTATIC REPAIR

## Brake Linkage Adjustment

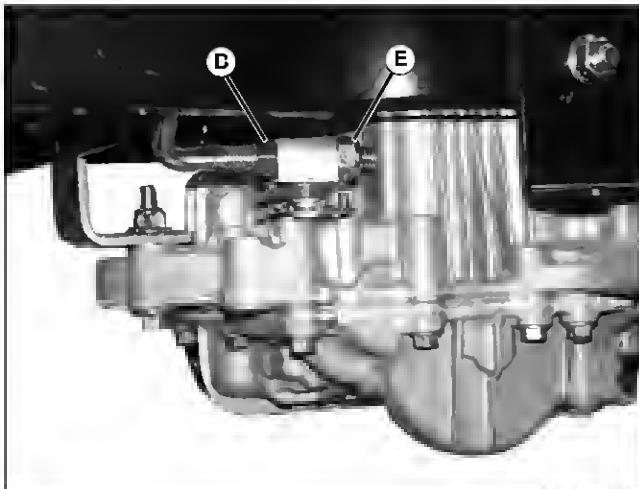
1. Park machine on level surface.
2. Set park brake.
3. Turn key switch to STOP position.
4. Remove mower deck. See "Mower Deck Removal and Installation" for the appropriate mower deck in the Attachments section.



MX37664

5. With the park brake engaged, measure the gap (A) between the brake rod compression spring bracket (B) and the tabs (C) on the brake rod. The gap should be at least 2mm (0.08 in.).

6. If the gap is not to specification:



MX37130

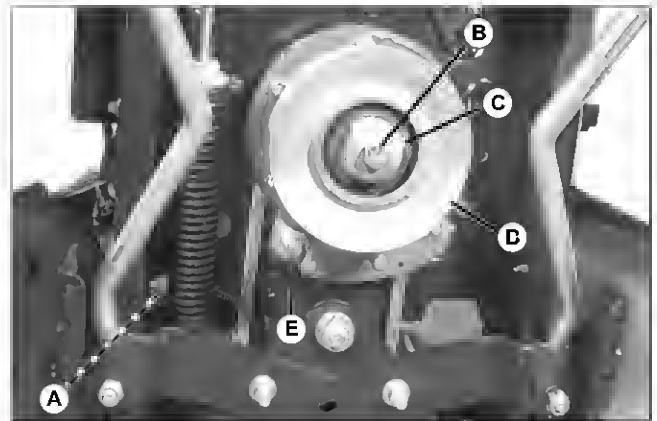
- Loosen jam nut (D).
- Turn lock nut (E) to adjust gap (A) to specification. Tighten jam nut (D).
- Release and set park brake and recheck the gap. Adjust as necessary.

## Repair

### PTO Clutch Removal and Installation

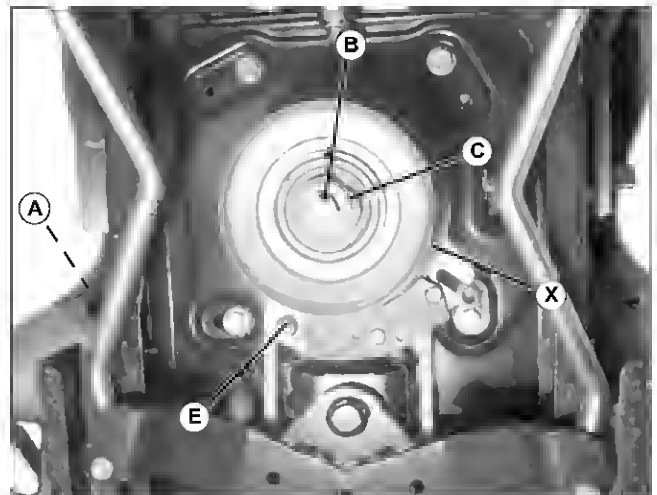
#### Removal:

1. Park machine safely on a flat surface. See "Park Machine Safely" in the Safety section.
2. Remove mower deck, if installed. See "Repair" on page 523 in the Attachments section.
3. Disconnect negative (-) cable from battery.
4. Lock park brake to relieve tension on traction drive belt.
5. Raise and securely block front of machine to gain access to the PTO Clutch.



MX37047

(SN -085000)



MX39872

(SN 085000-)

6. Disconnect wiring connector (A) to electric PTO clutch.

**Note:** Route the clutch wire harness through the frame. Use retainers to keep the harness from contacting the drive belt.

# POWER TRAIN - HYDROSTATIC REPAIR

7. Remove cap screw (B), bevel washer (C), and electric PTO clutch (D) from engine output shaft.
8. Inspect clutch. If worn or damaged replace entire unit. The clutch has no serviceable components.

## Installation:

1. Be sure key is in bore of clutch.
2. Install clutch (D), on shaft making sure anti-rotation pin (E) is through slot in deck.
3. Install washer (C) with concave side toward PTO clutch (D). Secure to shaft with cap screw (B).
4. Tighten cap screw (B) to specification.
5. Thread PTO clutch wiring harness through hole in deck. Secure harness on either side of deck so that it does not contact drive belt.

## Torque Specification:

Clutch Cap Screw . . . . . 72 N•m (53 lb-ft)

## Traction Drive Belt Removal and Installation (SN -085000)

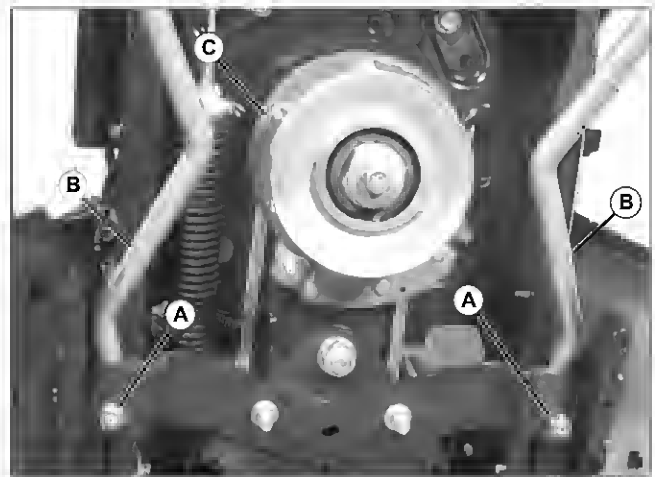
### Removal:

1. Park machine safely on a flat surface. See "Park Machine Safely" in the Safety section.
2. Remove mower deck, if installed. See "Repair" on page 523 in the Attachments section.
3. Disconnect negative (-) cable from battery
4. Unlock park brake.



**Caution: Avoid Injury! Tensioning spring is under high tension. Wear gloves and use a firm grip when stretching spring!**

5. Unhook traction spring from frame anchor at rear of machine.
6. Raise front of machine. Support safely.

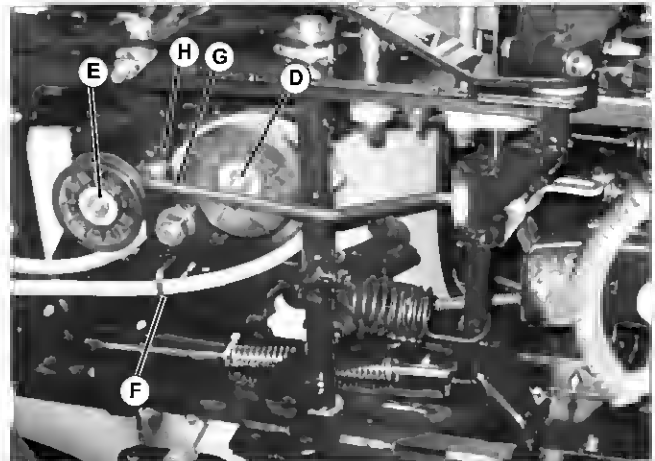


MX36326

7. Remove nuts (A) and tie rods (B) from steering arm.

**Note: If it is necessary to remove PTO clutch, refer to "PTO Clutch Removal and Installation" on page 394.**

8. Remove drive belt from around engine sheave (C).
9. Route the drive belt back around the brake and deck lift linkage toward the tensioner.



MX36327

10. Loosen nut (D) on V-Idler. Remove belt from around V-Idler.
11. Loosen nut (E) on flat idler. Remove belt from around flat idler.
12. Remove screw securing transaxle belt guide (F). Remove belt guide to remove belt from around transaxle sheave.
13. Remove spring clip (H) from tensioner end of the clutch linkage (G). Disconnect linkage from tensioner.
14. Remove entire belt from under machine.
15. Inspect belt for wear or damage. Replace as necessary.

# POWER TRAIN - HYDROSTATIC REPAIR

## Installation:

- Installation is the reverse of removal.
- Test function by engaging and disengaging brake pedal (releasing tension on belt). Make sure belt is running on all idlers/sheaves.

## Torque Specification:

Clutch Cap Screw . . . . . 72 N•m (53 lb-ft)

## Traction Drive Belt Removal and Installation (SN 085001-)

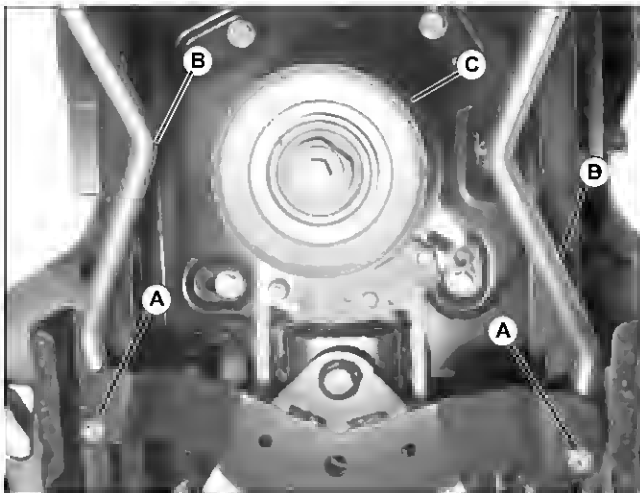
### Removal:

1. Park machine safely on a flat surface. See "Park Machine Safely" in the Safety section.
2. Remove mower deck, if installed. See "Repair" on page 523 in the Attachments section.
3. Disconnect negative (-) cable from battery



**Caution: Avoid Injury! Tensioning spring is under high tension. Wear gloves and use a firm grip when stretching spring!**

4. Unhook traction tensioner spring from frame anchor at rear of machine.
5. Raise front of machine. Support Safely.

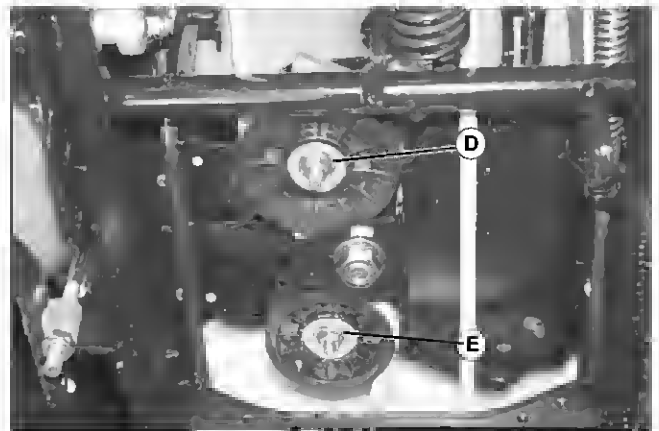


MX39872

6. Remove nuts (A) and tie rods (B) from steering arm.

**Note: If it is necessary to remove PTO clutch, refer to "PTO Clutch Removal and Installation" on page 394.**

7. Remove drive belt from around engine sheave (C).
8. Route the drive belt back around the brake and deck lift linkage toward the tensioner.



MX39873

9. Loosen nut (D) on V-Idler. Remove belt from around V-Idler.
10. Loosen nut (E) on flat idler. Remove belt from around flat idler.
11. Remove entire belt from under machine.
12. Inspect belt for wear or damage. Replace as necessary.

### Installation:

- Installation is the reverse of removal.

## Torque Specification:

Clutch Cap Screw . . . . . 72 N•m (53 lb-ft)

## Traction Drive Belt Tensioner Removal and Installation (SN -085000)

### Removal:

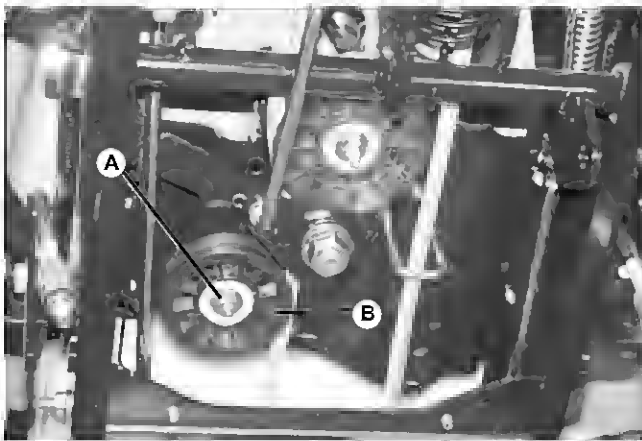
1. Park machine safely on a flat surface. See "Park Machine Safely" in the Safety section.
2. Disconnect negative (-) cable from battery
3. Remove mower deck, if installed. See "Repair" on page 523 in the Attachments section.
4. Lock park brake to relieve tension on traction drive belt.



**Caution: Avoid Injury! The machine may fall or slip from an unsafe lifting or holding devices!**

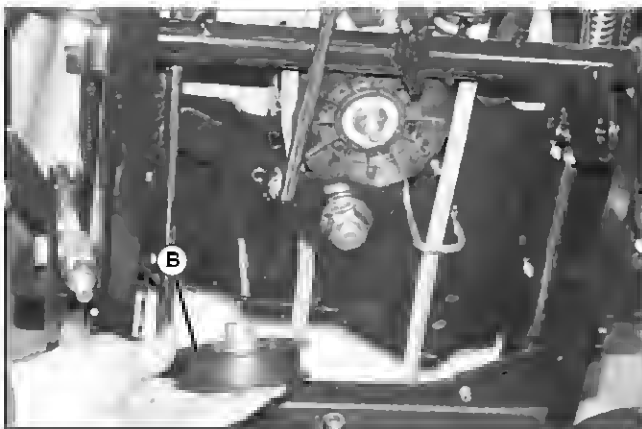
5. Raise front of machine. Support safely.

# POWER TRAIN - HYDROSTATIC REPAIR



MX37096

6. Loosen nut (A) on flat-idler (B).



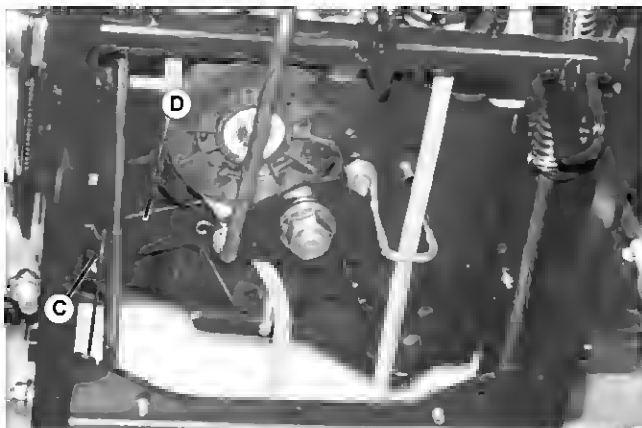
MX37097

7. Remove flat-idler (B).

8. Unlock parking brake.

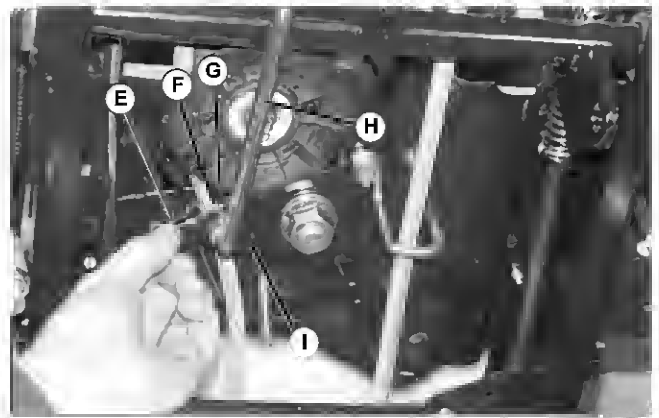


**Caution: Avoid Injury! Tensioning spring (C) is under high tension. Wear gloves and use a firm grip when stretching spring.**



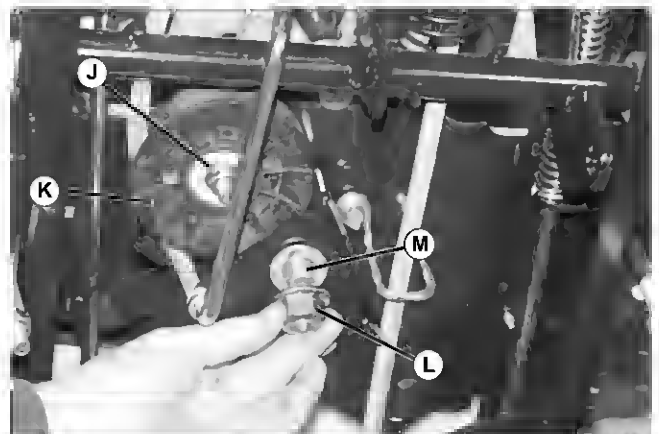
MX37098

9. Unhook spring (C) from idler bracket arm (D).



MX37099

10. Remove clip (E) washer (F) and plastic bushing (G) from end of link (H) and remove link from lower idler arm (I).



MX37100

11. Loosen nut (J) securing V-idler (K) to idler bracket. Remove belt from V-idler.

12. Remove nut (L) securing idler bracket to frame.

13. Remove idler bracket:

- SN -40000: Remove idler bracket and wave washer from idler shaft (M).
- SN 40001-: Remove idler bracket, spring washer and bushing from idler pivot bolt (M).

14. Inspect all components for wear or damage. Replace, as necessary

## Installation:

- Installation is the reverse of removal.
- Install V-idler (K) onto idler bracket before installing idler bracket. It is not necessary to tighten V-idler nut at this time.



**Caution: Avoid Injury! Tensioning spring (C) is under high tension. Wear gloves and use a firm grip when stretching spring.**

- Making sure parking brake is not locked, connect

# POWER TRAIN - HYDROSTATIC REPAIR

tensioning spring (C) to idler bracket arm (D).

- Test function by pressing and releasing brake/clutch pedal several times. Check to make sure belt is riding correctly on all sheaves and idlers.
- Tighten all nuts to specifications.

## Torque Specifications:

Idler Nut . . . . .	26 N•m (19 lb-ft)
Idler Bracket . . . . .	68 N•m (50 lb-ft)

## Traction Drive Belt Tensioner Removal and Installation (SN 085001-)

### Removal:

1. Park machine safely on a flat surface. See "Park Machine Safely" in Safety Section.
2. Disconnect negative (-) cable from battery
3. Remove mower deck, if installed. See "Repair" on page 523 in the Attachments section.

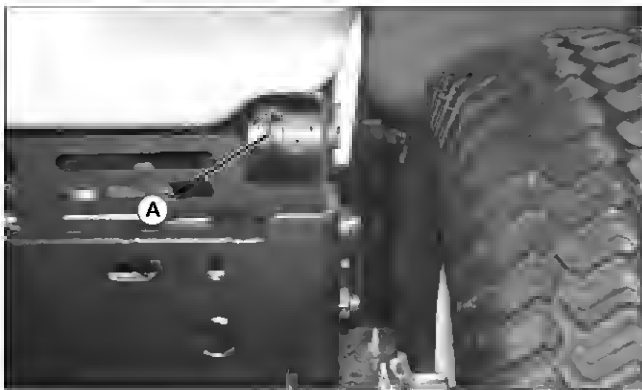


**Caution: Avoid Injury! The machine may fall or slip from an unsafe lifting or holding devices!**

4. Raise front of machine. Support safely.

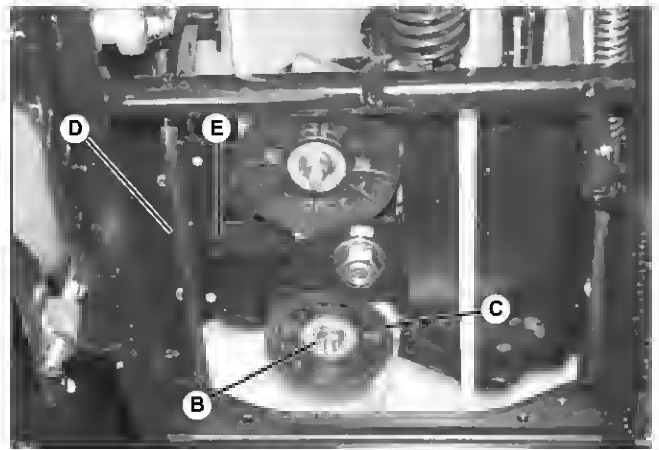


**Caution: Avoid Injury! Tensioning spring is under high tension. Wear gloves and use a firm grip when stretching spring!**



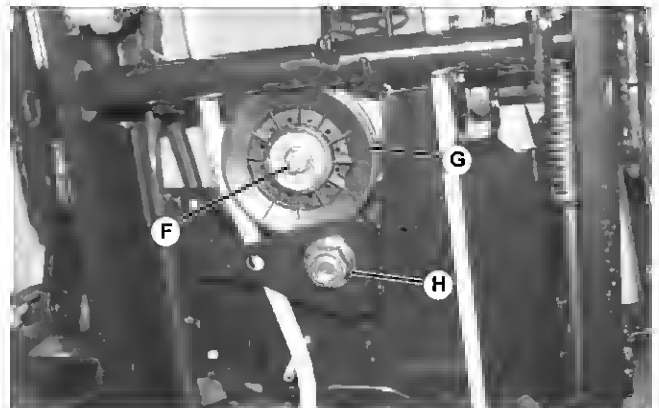
MX39874

5. Unhook traction tensioner spring from frame anchor (A) at rear of machine.



MX39873

6. Loosen nut (B) on flat-idler (C).
7. Unhook spring (D) from idler bracket arm (E).



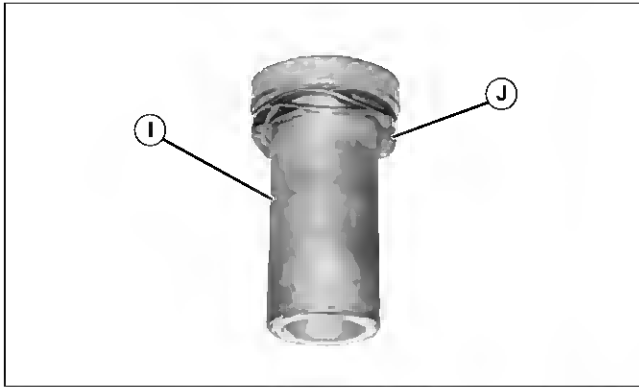
MX39875

8. Loosen nut (F) securing V-idler (G) to idler bracket. Remove belt from V-idler.
9. Remove nut (H) securing idler bracket to frame.
10. Remove idler bracket, spring washer and bushing from idler pivot bolt.
11. Inspect all components for wear or damage. Replace, as necessary

### Installation:

- Installation is the reverse of removal.

# POWER TRAIN - HYDROSTATIC REPAIR



MX39876

- Ensure that bushing (I) and wave washer (J) is installed in the orientation shown into the idler bracket before installing onto machine.
- Install V-idler (G) onto idler bracket before installing idler bracket. It is not necessary to tighten V-idler nut at this time.



**Caution: Avoid Injury! Tensioning spring (C) is under high tension. Wear gloves and use a firm grip when stretching spring.**

- Connect tensioning spring (D) to idler bracket arm (E).
- Check to make sure belt is riding correctly on all sheaves and idlers.
- Tighten all nuts to specifications.

## Torque Specifications:

Idler Nut . . . . .	26 N•m (19 lb-ft)
Idler Bracket . . . . .	68 N•m (50 lb-ft)

## Forward /Reverse Pedal Removal and Installation (SN -085000)

### Removal:

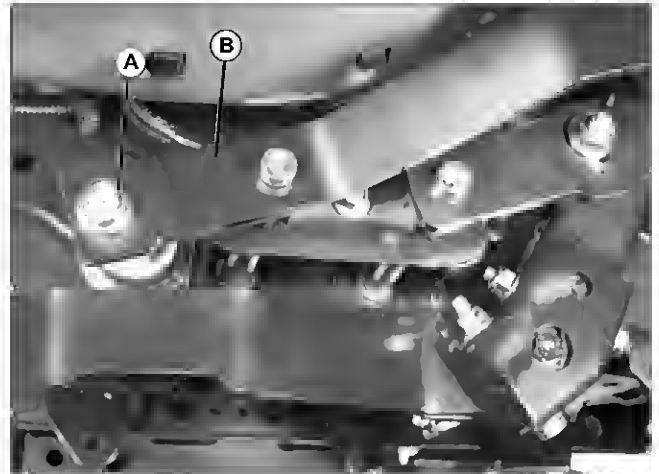
1. Park machine on safely a flat surface. See "Park Machine Safely" in the Safety section.
2. Remove mower deck, if installed. See "Repair" on page 523 in the Attachments section.
3. Disconnect negative (-) cable from battery



**Caution: Avoid Injury! The machine may fall or slip from an unsafe lifting or holding devices!**

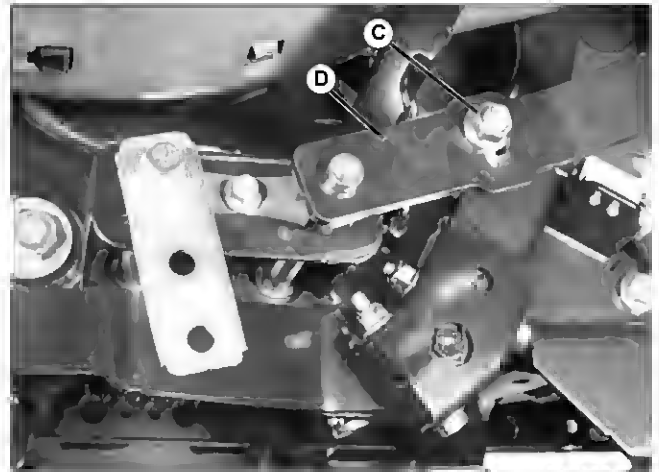
4. Raise front or rear of machine. Support on jack stands.

**Note: Location and orientation of hardware and linkage of forward/reverse pedal assembly during this procedure.**



MX38255

5. Remove nut (A) from reverse pedal (B). Remove pedal.



MX38256

6. Remove nut (C) from forward pedal (D). Remove pedal.

### Installation:

Installation is in reverse order of removal.

- Be sure to perform centering procedure after disassembling or working on foot pedal components.
- Adjust pedal height (deck to bottom of pedal) to specification.
- Tighten all fasteners to specifications

Test drive system. See "Traction Drive System Test" on page 391.

### Torque Specifications:

Forward Pedal-to-Foot Mat Height . . . . .	56 mm (2.2 in.)
Reverse Pedal-to-Foot Mat Height . . . . .	41 mm (1.6 in.)
Pedal Cap Screw . . . . .	68 N•m (50 lb-ft)
Pedal Pivot Rod Lock Nut . . . . .	45 N•m (33 lb-ft)

# POWER TRAIN - HYDROSTATIC REPAIR

## Forward/Reverse Pedal Removal and Installation (SN 085001-)

### Removal:

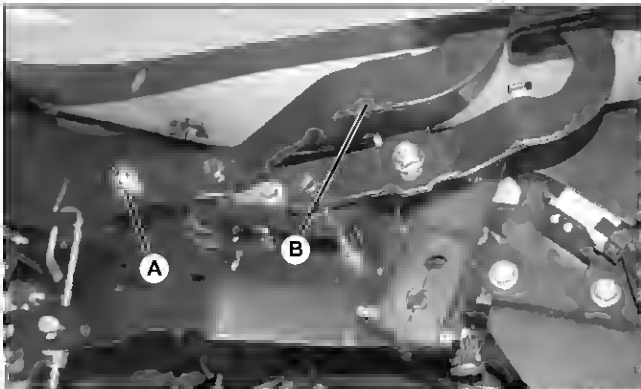
1. Park machine on safely a flat surface. See "Park Machine Safely" in the Safety section.
2. Remove mower deck, if installed. See "Repair" on page 523 in the Attachments section.
3. Disconnect negative (-) cable from battery.



**Caution: Avoid Injury! The machine may fall or slip from an unsafe lifting or holding devices!**

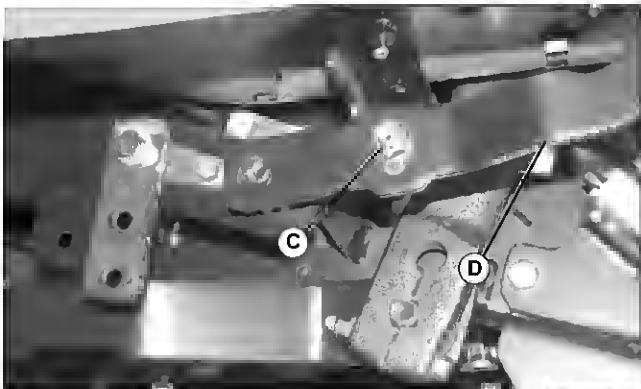
4. Raise front or rear of machine. Support on jack stands.

**Note: Location and orientation of hardware and linkage of forward/reverse pedal assembly during this procedure.**



MX39877

5. Remove nut (A) from reverse pedal (B). Remove pedal.



MX39878

6. Remove nut (C) from forward pedal (D). Remove pedal.

### Installation:

Installation is in reverse order of removal.

- Be sure to perform centering procedure after disassembling or working on foot pedal components.

- Tighten all fasteners to specifications.

Test drive system. See "Traction Drive System Test" on page 391.

### Torque Specifications:

**Pedal Cap Screw . . . . . 68 N•m (50 lb-ft)**

**Pedal Pivot Rod Lock Nut . . . . . 45 N•m (33 lb-ft)**

## Cruise Control Removal and Installation

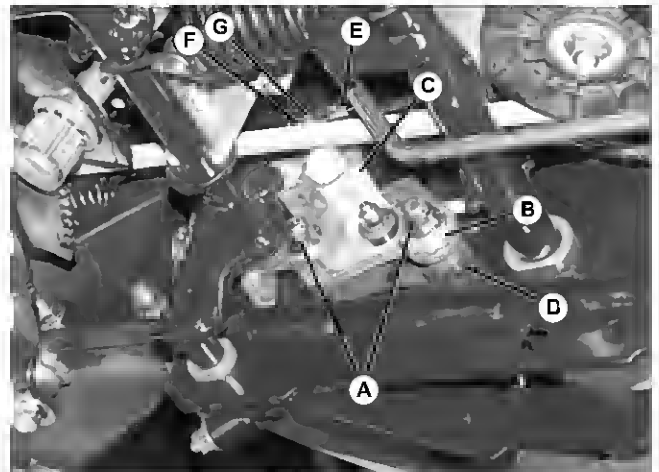
### Removal:

1. Park machine on safely a flat surface. See "Park Machine Safely" in the Safety section.
2. Remove mower deck, if installed. See "Repair" on page 523 in the Attachments section.
3. Disconnect negative (-) cable from battery.



**Caution: Avoid Injury! The machine may fall or slip from an unsafe lifting or holding devices!**

4. Raise front or rear of machine. Support on jack stands.

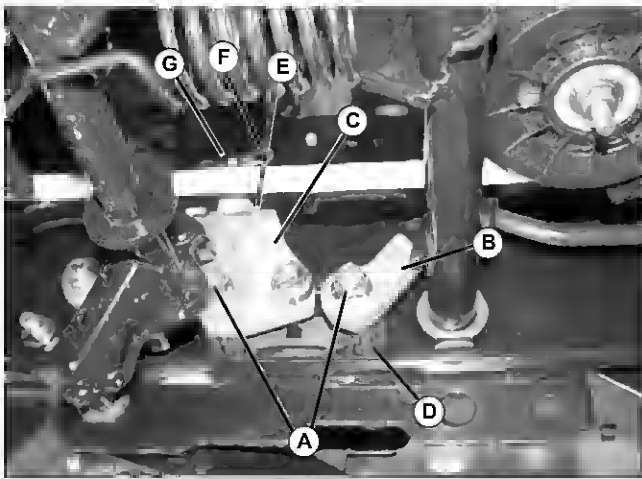


MX37139

**SN -085000**



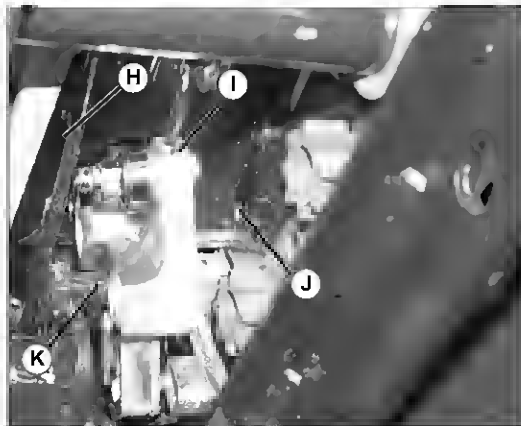
# POWER TRAIN - HYDROSTATIC REPAIR



MX39881

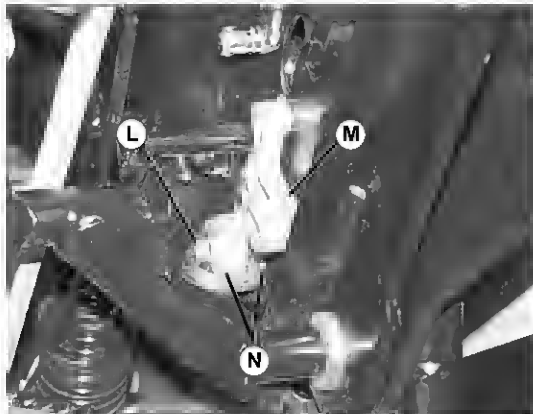
SN 085001-

5. Remove lock nuts (A) from control rods. Note orientation of reverse lever (B) and cam plate (C). Remove rods from bushing (D) and cruise control bracket (E).
6. Remove spring clip (F) and washer (G) from control rod.



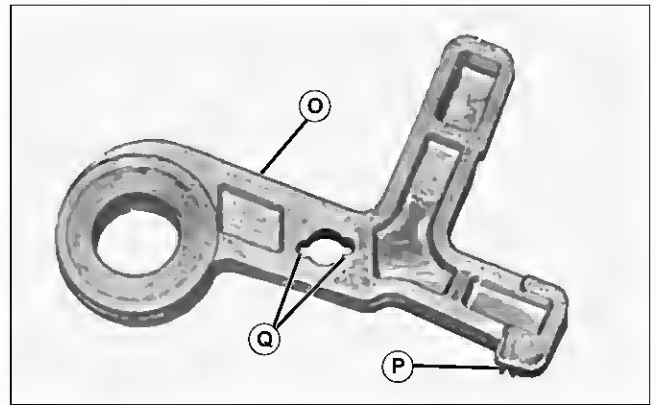
MX37140

7. Push spring rod (H) up to clear end of cam plate (I) and maneuver cam plate to clear slot (J) and rod (K).



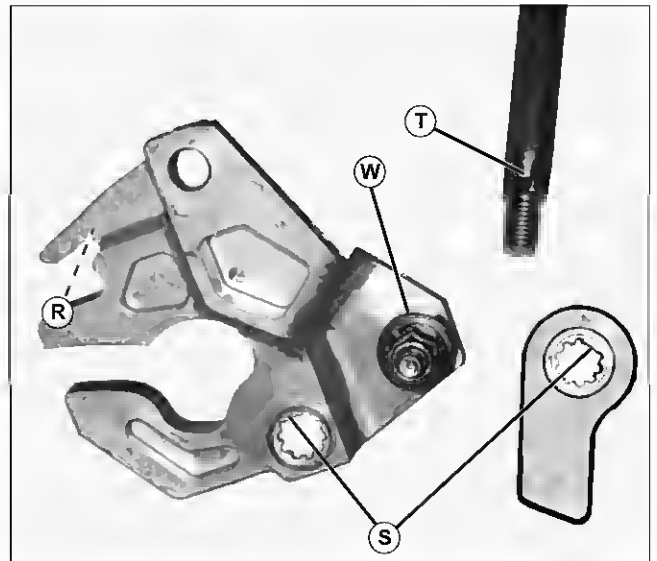
MX37140

8. Remove bolt (L) securing cruise control lock (M) to frame. Remove cruise control lock and two bushings (N).



MX37186

9. Inspect cruise control lock (O) paying special attention to teeth (P). If damaged replace. Note locking ears (Q) that engage end of cruise control lock rod.



MX37185

10. Inspect cam plate paying special attention to teeth (R). If damaged, replace plate.

**Note:** Location of skip tooth spline (S) and matching recess (T) in shaft for assembly. Shafts and plate splines must line up correctly or damage to plates could occur.

11. Inspect splines (S) and shaft (T) for damage. Replace as required.
12. Inspect cam bearing (W) to insure that it turns freely. If not, replace.
13. Inspect all surfaces for damage and wear or damage. Replace as necessary.

## Installation:

Installation is in reverse order of removal.

# POWER TRAIN - HYDROSTATIC REPAIR

**Note:** Location of skip tooth spline (S) and matching recess (T) in shaft for assembly. Shafts and plate splines must line up correctly or damage to plates could occur.

- Tighten all fasteners to specifications
- Test drive system. See "Traction Drive System Test" on page 391.

## Torque Specifications:

Cruise Control Pivot Cap Screw . . . . 32.5 N•m (24 lb-ft)  
Pedal Pivot Rod Lock Nut . . . . . 45 N•m (33 lb-ft)  
Cam Follower Cap Screw. . . . . 23 N•m (17 lb-ft)

## Brake Pedal and Cross Shaft Removal and Installation

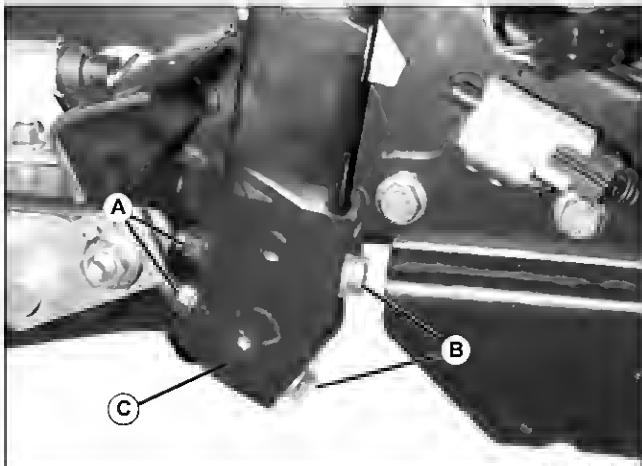
### Removal:

1. Remove mower deck. See "Mower Deck Removal and Installation" for the appropriate mower deck in the Attachments section.
2. Remove fender deck. See "Fenderdeck Removal and Installation" on page 566 in Miscellaneous section.
3. Disconnect negative (-) cable from battery.



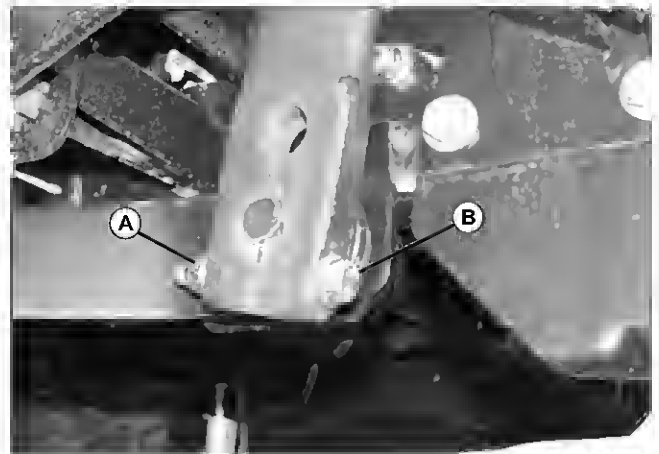
**Caution: Avoid Injury! The machine may fall or slip from an unsafe lifting or holding devices!**

4. Raise front of machine. Support on jack stands.



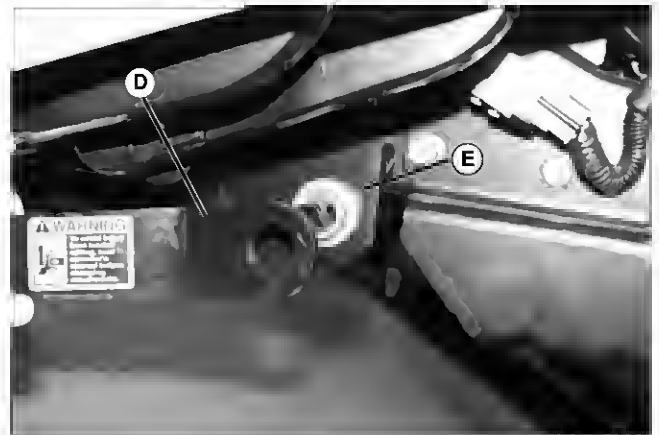
MX37262A

5. SN -85000: Remove nuts (A) and bolts (B) from pedal. Remove cover (C). Remove pedal from shaft.



MX39871

6. SN 85001-: Remove nut (A) and bolt (B) from pedal. Remove pedal from shaft.



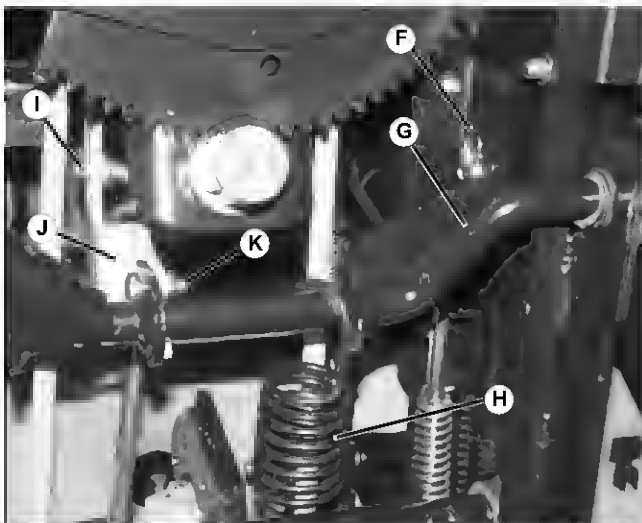
MX37699

7. Remove right side lift arm (D) from pedal shaft bushing (E). Remove bushing.



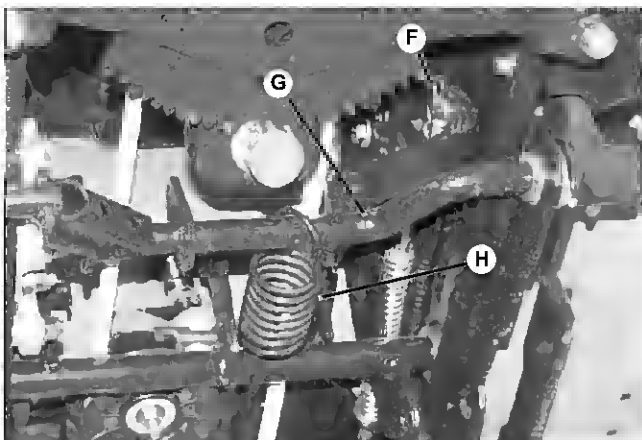
**Caution: Avoid Injury! The brake spring is under high tension when installed. Wear approved eye protection and gloves when removing to minimize the risk of personal injury.**

# POWER TRAIN - HYDROSTATIC REPAIR



MX37700

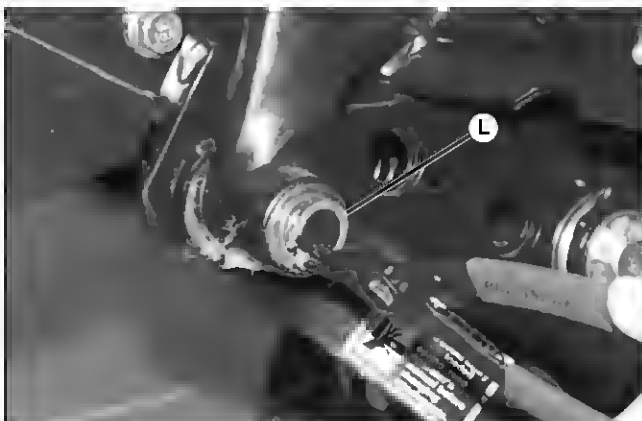
**SN -085000**



MX39879

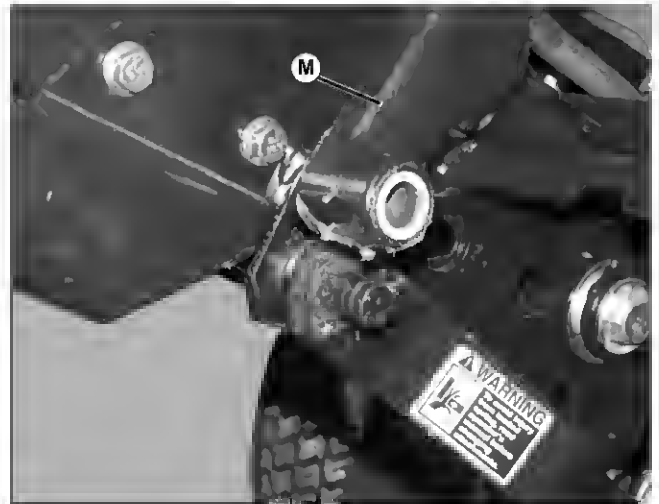
**SN 085001-**

8. Remove spring (H) from cross shaft (G).
9. Remove spring pin (F). Disconnect the brake rod.
10. SN -085000: Remove spring pin and washer (I) and disconnect the clutch rod. Remove nut and carriage bolt (K) and remove arm (J).



MX37701

11. Remove snap ring and washer (L) securing attachment lift pedal.



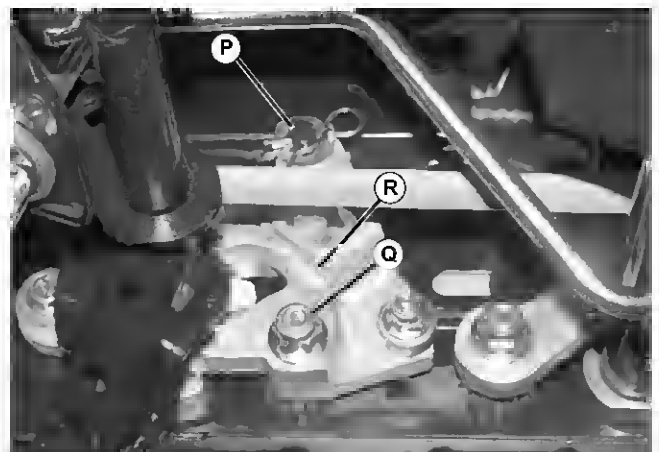
MX37704

12. Remove lift pedal (M).



MX37703

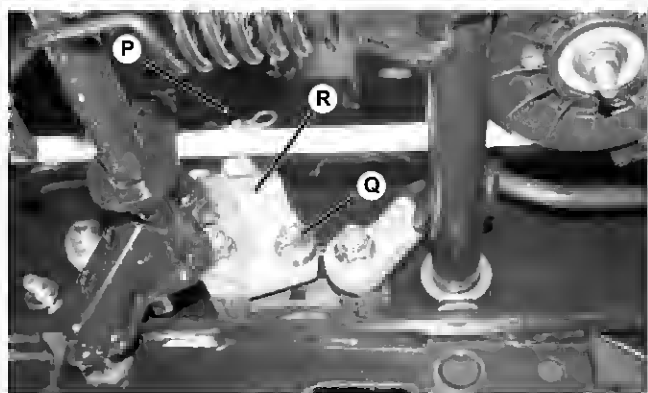
13. Remove left side lift arm (N) and bushing (O).



MX37706

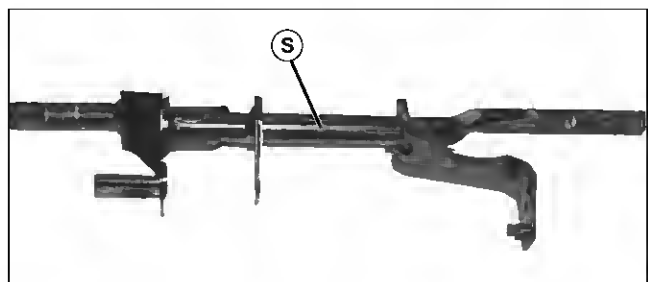
**SN -085000**

# POWER TRAIN - HYDROSTATIC REPAIR



## SN 085001-

14. Remove spring pin and washer from hydro control rod (P) and disconnect rod.
15. Remove lock nut (Q).
16. Remove cam plate (R).



17. Remove the shaft (S) from the frame.
18. Inspect components. Replace any worn or damaged parts.

## Installation:

Installation is the reverse of removal.

- SN -85000: The top brake pedal mounting bolt should be tightened before the bottom mounting bolt.
- Tighten brake pedal mounting bolt(s) to 60 N•m (44 lb-ft).

## Transaxle Removal and Installation - X300, X320, X340

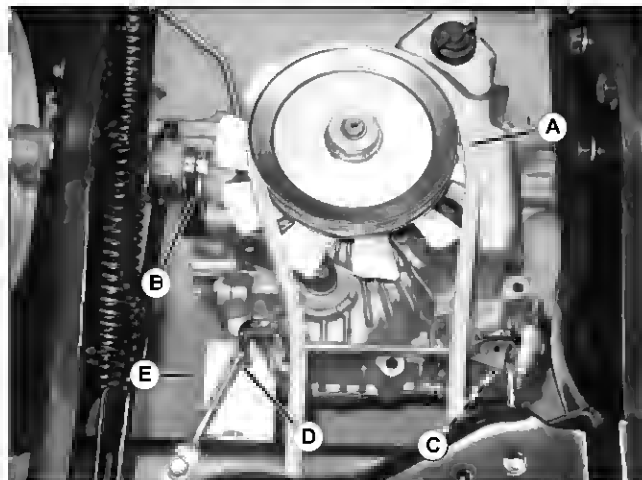
### Removal:

1. Park machine safely on a flat surface. See "Park Machine Safely" in the Safety section.
2. Disconnect negative (-) cable from battery



**Caution: Avoid Injury! The machine may fall or slip from an unsafe lifting or holding devices!**

3. Block front wheels to prevent machine from rolling when raised.
4. Remove fender deck. See "Fenderdeck Removal and Installation" on page 566 in Miscellaneous section.
5. Remove fuel tank. See "Fuel Tank Removal and Installation" on page 567 in the Miscellaneous section.

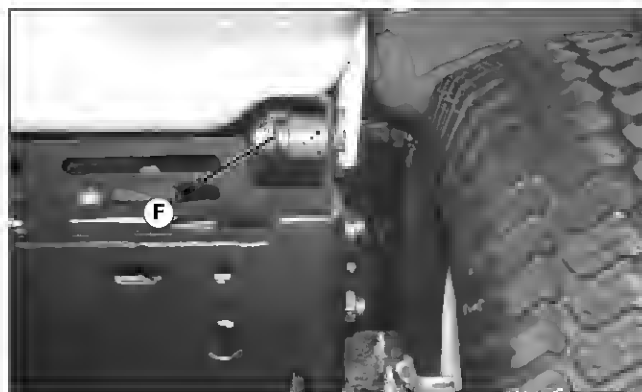


## Belt guide is not present on SN 085001-

6. SN -085000: Lock park brake to relieve tension on traction drive belt (A).



**Caution: Avoid Injury! Tensioning spring is under high tension. Wear gloves and use a firm grip when stretching spring!**

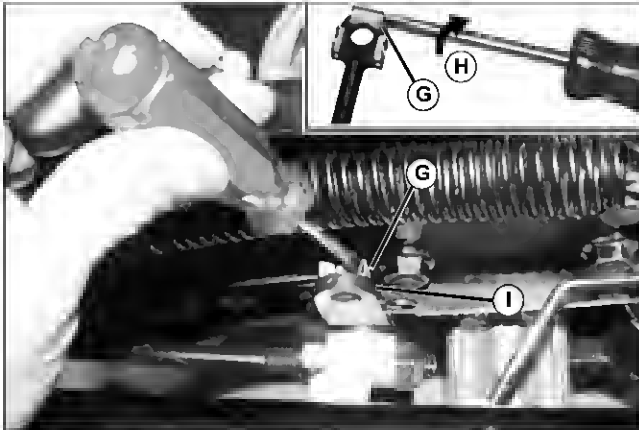


7. SN 085001-: Unhook traction tensioner spring from frame anchor (F) at rear of machine.
8. Remove drive belt from sheave and route clear of transmission. Unlock park brake.
9. Remove spring pin (B) and washer. Remove directional control rod end from transmission control arm.
10. Remove spring pin (C) and washer securing brake link to transmission arm.

# POWER TRAIN - HYDROSTATIC REPAIR

11. Remove nut (D) and bolt securing front transmission mount (E) to transmission.

12. Models with external dampener:



- Insert small flat blade screw driver into end of clip (G) on damper rod end and rotate in direction (H) to remove clip from groove in end of pin (I). Remove damper rod end from pin.

**Important: Avoid Damage! During transaxle removal, rear of machine must be supported by the frame.**

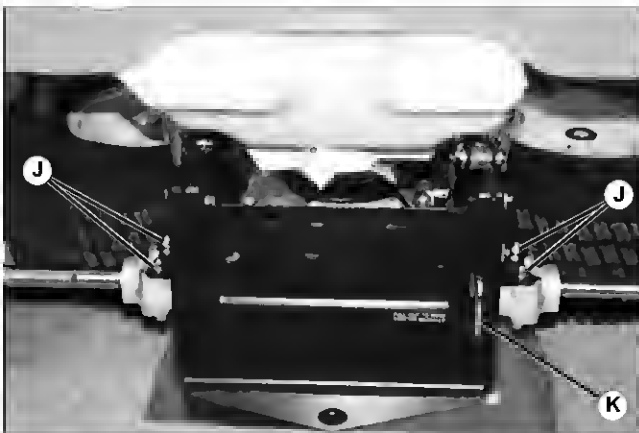
13. Raise rear of machine. Support by the frame using suitable stands.

14. Remove rear wheels. See "Rear Wheel Removal and Installation - X300, X320, X340 and X360" on page 562 in the Miscellaneous section.



**Caution: Avoid Injury! The machine may fall or slip from an unsafe lifting device.**

**Transmission is heavy. Support transmission before removing mounting bolts.**



15. Remove bolts (J) and nuts holding transaxle to frame. Carefully lower transaxle housing from frame, tilting front

end down to allow freewheel rod (K) to clear frame.

**Important: Avoid Damage! When removing transaxle, be careful to move transaxle appropriately to remove freewheel rod from back of machine frame.**

16. Inspect transaxle control arms and transaxle sheave and fan. Replace as necessary.

## Installation:

- Installation is the reverse of removal.

**Important: Avoid Damage! When installing transaxle, be careful to move transaxle appropriately to install freewheel rod through back of machine frame.**

- Install bolts (J) and nuts securing transaxle to frame. Tighten nuts on both sides of machine to specifications.
- Install bolt and nut (D) securing front of transaxle. Tighten to specification.

**Note: When putting brake rod back onto transaxle control arm, it will be necessary to adjust brake rod.**

- Install rear wheels. See "Rear Wheel Removal and Installation - X300, X320, X340 and X360" on page 562 in the Miscellaneous section.
- Install fender deck. See "Fenderdeck Removal and Installation" on page 566 in Miscellaneous section.
- Install fuel tank. See "Fuel Tank Removal and Installation" on page 567 in the Miscellaneous section.
- Lower machine and install mower deck. See "Repair" on page 523 in the Attachments section.

## Torque Specification:

**Transaxle Mounting Bolts . . . . . 32.5 N•m (24 lb-ft)**

## Transaxle Removal and Installation - X304, X324

### Removal:

1. Park machine on safely a flat surface. Turn engine OFF, remove key, and engage parking brake. See "Park Machine Safely" in the Safety section.
2. Disconnect negative (-) cable from battery.
3. SN -085000: Engage park brake to relieve tension on traction drive belt.



**Caution: Avoid Injury! Tensioning spring is under high tension. Wear gloves and use a firm grip when stretching spring!**

## POWER TRAIN - HYDROSTATIC REPAIR

4. SN 085001-: Unhook traction tensioner spring from frame anchor (F) at rear of machine.



**Caution: Avoid Injury! The machine may fall or slip from an unsafe lifting or holding devices!**

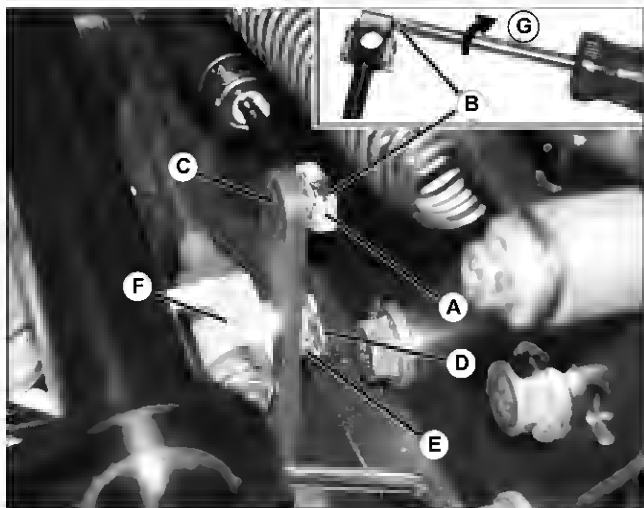
5. Block front wheels to prevent machine from rolling when raised.

**Important: Avoid Damage! During transaxle removal, rear of machine must be supported by the frame.**

6. Raise rear of machine. Support using suitable stands.

7. Remove rear wheels. See "Rear Wheels Removal and Installation - X304 and X324" on page 562 in the Miscellaneous section.

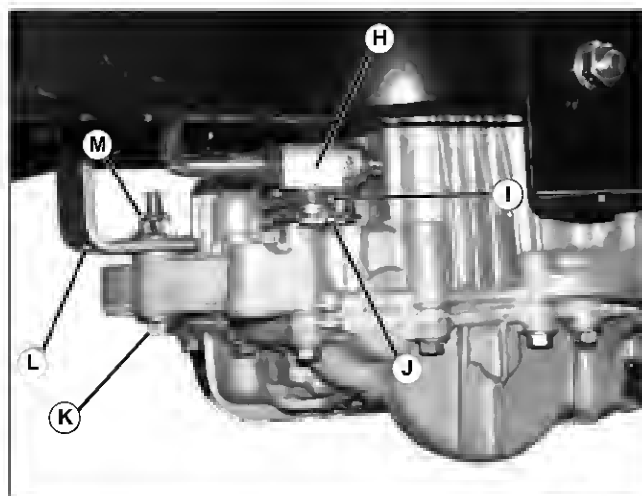
8. Remove rear steering linkage See "Rear Steering Linkage Removal and Installation - X304, X324" on page 464 in Steering Section.



MX37135

9. From the right rear side of machine, loosen clip (A) on damper rod by inserting a flat blade screw driver at (B) and turning in direction (G). Remove damper rod end from arm (C).

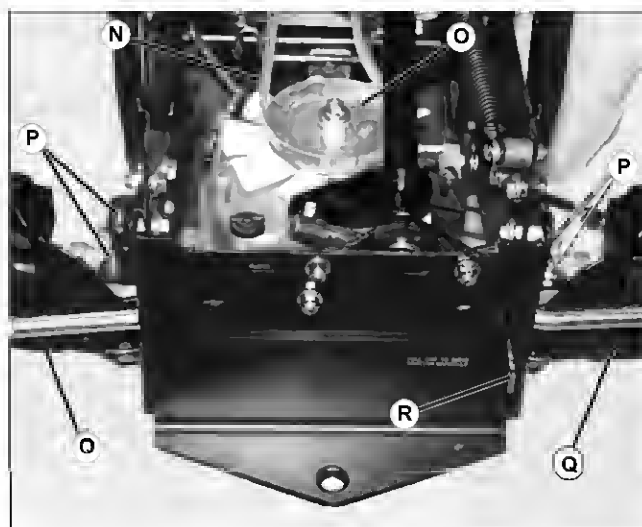
10. Remove clip (D) and washer (E). Remove link (F) from arm (C).



MX37130

11. From left underside of machine remove clip (J) and washer securing brake link (H) to transmission arm (I).

12. Remove nut (M) and bolt (K) securing front transmission mount (L) to transmission.



MX37136

13. Remove drive belt (N) from transmission input sheave (O).



**Caution: Avoid Injury! The machine may fall or slip from an unsafe lifting device:**

- Transmission and axle carrier are heavy. Support transmission before removing mounting bolts.
- Axle carrier is fastened by the same bolts that hold transmission to frame. Be careful when removing bolts that axle carrier does not fall.

14. Safely support transmission and axle carrier.

# POWER TRAIN - HYDROSTATIC REPAIR

**Important: Avoid Damage! When removing transaxle, tilt the transaxle to remove the freewheel rod (R) from back of machine frame.**

15. Remove nuts (P) and bolts securing transmission and rear axle carrier (Q) to frame. Tilt transmission. Remove without damaging freewheel rod (R).

16. Inspect transaxle control arms, transaxle sheave and fan. Replace as necessary.

## Installation:

- Installation is the reverse of removal.

**Important: Avoid Damage! When installing transaxle, align the freewheel rod (R) through back of machine frame.**

- Install bolts (P) and nuts securing transaxle to frame. Install bolt (M) and nut (K) for front transmission mount (L). Tighten fasteners to specification.

**Note: When putting brake rod (H) back onto transaxle control arm, it will be necessary to adjust brake rod.**

- Install rear wheels. See "Rear Wheels Removal and Installation - X304 and X324" on page 562 in the Miscellaneous section.
- Lower machine and install mower deck, if installed. See "Repair" on page 523 in the Attachments section.

## Torque Specification:

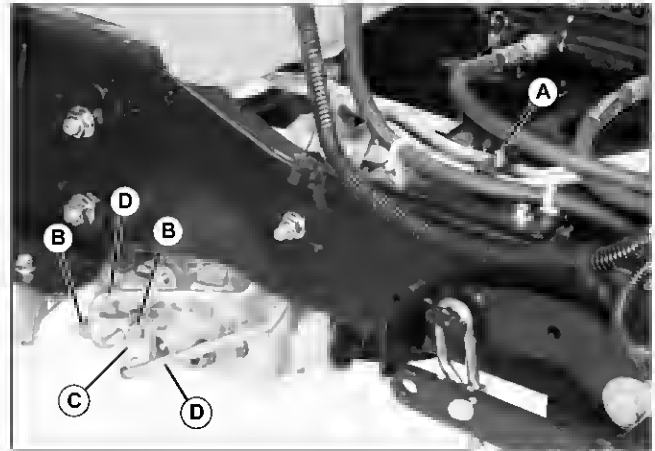
**Transaxle-to-Hitch Plate Mounting Bolts** 32 N•m (24 lb-ft)

**K58 Front Strap Bolt.** . . . . . 64 N•m (47 lb-ft)

## Transaxle Removal and Installation - X360

### Removal:

1. Park machine safely on a flat surface. See "Park Machine Safely" in the Safety section.
2. Disconnect negative (-) cable from battery
3. Remove mower deck. See Mower Deck Removal and Installation for the appropriate deck in the Attachments section.
4. Remove fender deck. See "Fenderdeck Removal and Installation" on page 566 in Miscellaneous section.
5. Remove fuel tank. See "Fuel Tank Removal and Installation" on page 567 in the Miscellaneous section.
6. Drain hydraulic fluid from transaxle. See "Changing Transaxle Oil and Filter (X360)" on page 429 in the Hydraulics section.

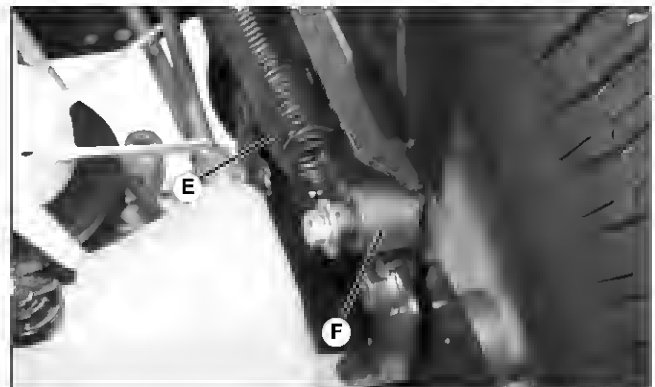


MX40447

7. Remove screw (A) and tube clamp retaining hydraulic lines to frame.
8. Remove two screws (B) and tube support (C) that secure hydraulic lines to transaxle. Mark lines to aid in later assembly.
9. Place a small clean container under the hydraulic lines and pull supply and return hydraulic lines (D) from ports in transaxle.



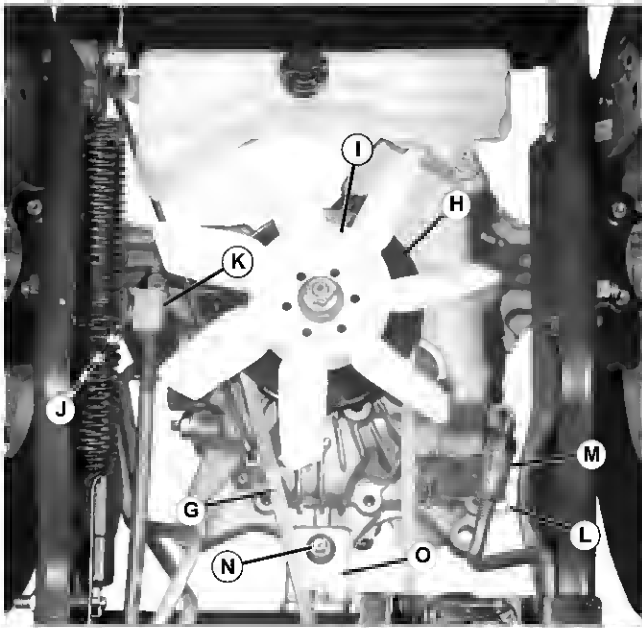
**Caution: Avoid Injury! Tensioning spring is under high tension. Wear gloves and use a firm grip when stretching spring!**



MX40392

10. Unhook traction tensioner spring (E) from frame anchor (F) at the rear of machine, right side.

## POWER TRAIN - HYDROSTATIC REPAIR



MX40394

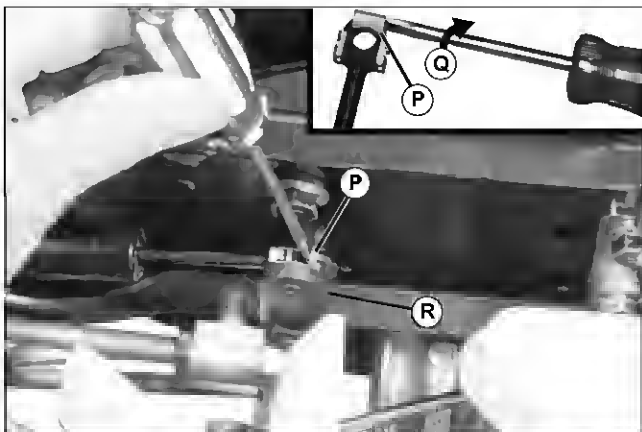
11. Remove the front end of the drive belt (G) from the drive pulley above the PTO clutch, and let it rest on the clutch. Then remove the belt from the transaxle sheave (H) and fan (I). Fold the end of the belt forward, clear of the transmission, and temporarily secure.

12. Unlock park brake.

13. Remove spring pin (J) and washer, and disconnect directional control rod end (K) from transmission control arm.

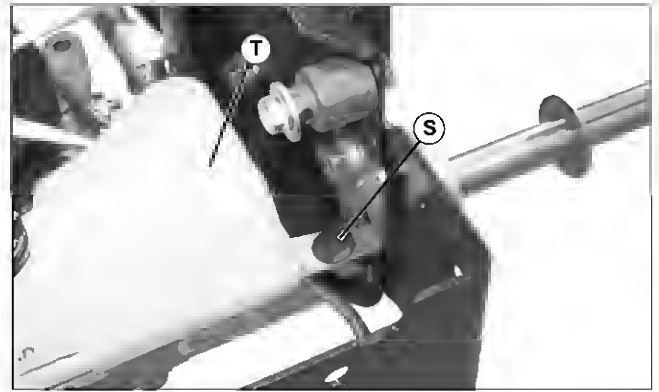
14. Remove spring pin (L), and disconnect brake link (M) from transmission arm.

15. Remove nut (N) and bolt securing front transmission mount (O) to transmission.



MX40588

16. Insert small flat blade screw driver into end of clip (P) on damper rod end and rotate in direction (Q) to remove clip from groove in end of pin on transmission control arm (R). Remove damper rod end from pin and pivot it forward, out of the way.



MX40589

17. Remove the plastic push pin (S) that secures the hydraulic reservoir (T) to the support bracket at the right side of the frame.



**Caution: Avoid Injury! The machine may fall or slip from an unsafe lifting or holding devices!**

18. Block front wheels to prevent machine from rolling when raised.



**Important: Avoid Damage! During transaxle removal, rear of machine must be supported by the frame.**

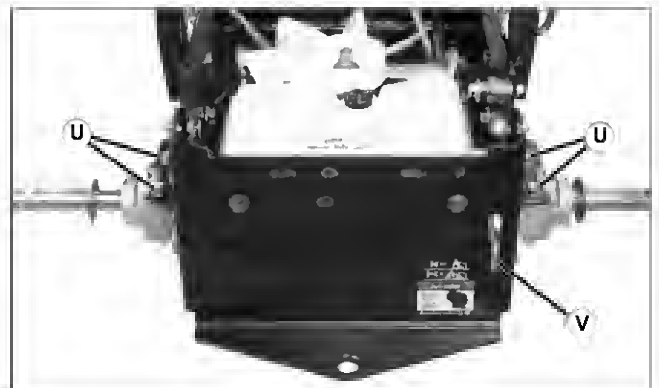
19. Raise rear of machine. Support under the frame using suitable stands.

20. Remove rear wheels. See "Rear Wheel Removal and Installation - X300, X320, X340 and X360" on page 562 in the Miscellaneous section.



**Caution: Avoid Injury! The machine may fall or slip from an unsafe lifting device.**

**Transmission is heavy. Support transmission before removing mounting bolts.**



MX40590

21. Remove nuts (U) and bolts holding transaxle to frame. Carefully tilt front of transaxle down, taking care to maneuver hydraulic reservoir away from frame bracket.



# POWER TRAIN - HYDROSTATIC REPAIR

Move transaxle forward and guide freewheel rod (V) through hole in frame, then lower transaxle to the ground.

**Important: Avoid Damage! When removing transaxle, be careful to move transaxle appropriately to remove freewheel rod from back of machine frame.**

22. Inspect transaxle control arms and transaxle sheave and fan. Replace as necessary.

## Installation:

Installation is the reverse of removal.

**Important: Avoid Damage! When installing transaxle, be careful to move transaxle appropriately to install freewheel rod through back of machine frame.**

- Install bolts (J) and nuts securing transaxle to frame. Tighten nuts on both sides of machine to specifications.

**Note: When putting brake rod back onto transaxle control arm, it will be necessary to adjust brake rod.**

- Install rear wheels. See "Rear Wheel Removal and Installation - X300, X320, X340 and X360" on page 562 in the Miscellaneous section.
- Install push pin securing hydraulic reservoir to support bracket.
- Secure damper rod to transmission control arm.
- Install bolt and nut (N) securing front of transaxle. Tighten to specification.
- Connect brake link to transmission control arm and secure with spring pin (L).
- Connect directional control rod end (K) to transmission control arm and secure with spring pin (J) and washer.
- Install traction drive belt over fan, onto transaxle sheave (H), then onto drive pulley above PTO clutch.
- Install traction tensioner spring (E) onto frame anchor (F).
- Install hydraulic lines in transaxle. Apply a light coat of grease on the O-rings before installation.
- Install fuel tank. See "Fuel Tank Removal and Installation" on page 567 in the Miscellaneous section.
- Install fender deck. See "Fenderdeck Removal and Installation" on page 566 in Miscellaneous section.
- Lower machine and install mower deck. See "Repair" on page 523 in the Attachments section.
- Fill transaxle with hydraulic fluid. See "Changing Transaxle Oil and Filter (X360)" on page 429 in Hydraulics section.

## Torque Specification:

Transaxle Mounting Bolts . . . . . 32.5 N•m (24 lb-ft)

K58H Front Strap Bolt . . . . . 64 N•m (47 lb-ft)

Hydraulic Line Retaining Plate Cap Screws . . 31.2 N•m (23 lb-ft)

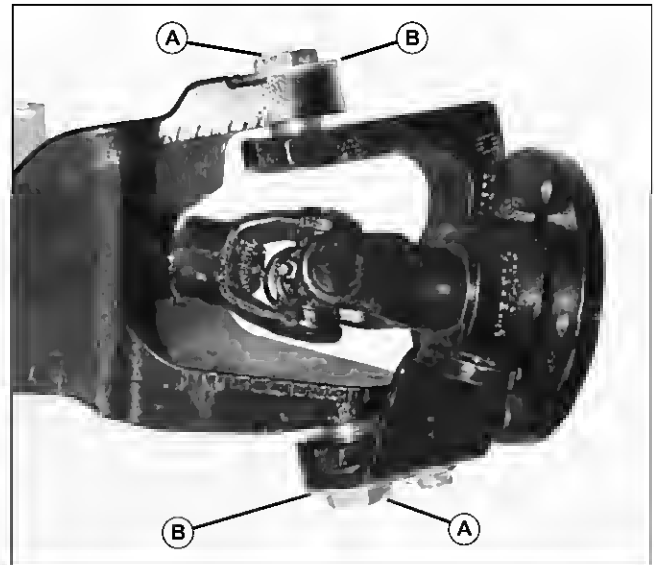
## Transaxle Carrier Removal and Installation

### Removal:

1. Remove transaxle from frame. See "Transaxle Removal and Installation - X304, X324" on page 405.

**Note: Number of stack washers (B) and shim washers used below upper and lower king pins. Shim washers may or may not be used.**

**Be sure that transaxle and carrier are adequately supported. Transaxle will pivot on second knuckle king pins when first side is removed.**



MX37555

**Picture Note: Right side knuckle from X324 shown.**

2. Remove upper and lower king pins (A) and washers (B), securing knuckle to transaxle carrier. For more information on knuckle disassembly. See "Rear Steering Knuckle Removal and Installation" on page 465 in Steering Section. Repeat on other side of transaxle carrier.
3. Remove nut (A) and tie rod (B).
4. Remove knuckles from splined end of transaxle output shafts.
5. Separate transaxle from carrier.

### Installation:

- Installation is the reverse of removal.

# POWER TRAIN - HYDROSTATIC REPAIR

## Specifications:

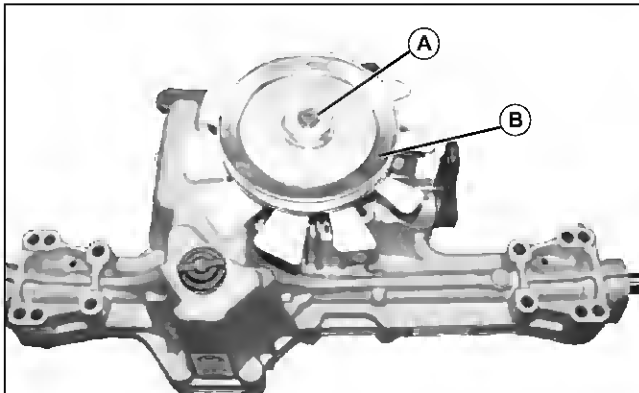
Tie Rod Ball Joint Nut .....	60 N•m (44 lb-ft)
Kingpin Bolt .....	150 N•m (203 lb-ft)

## Transaxle Components Disassembly K46

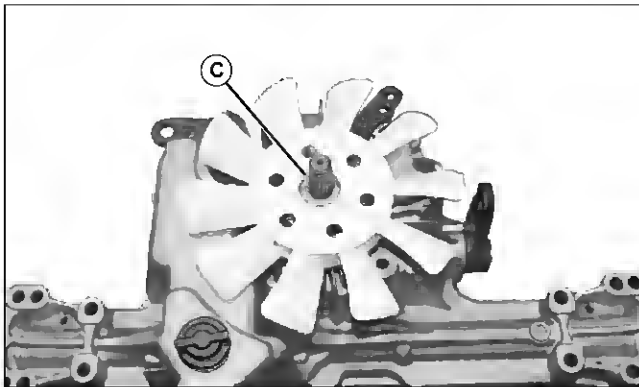
**Note:** Obtain transaxle seal kit before service is performed. Do not reuse seals.

### Fan and Sheave Disassembly:

1. Remove transaxle from machine. See "Transaxle Removal and Installation - X300, X320, X340" on page 404.
2. On X304 and X324 models remove transaxle carrier. See "Transaxle Carrier Removal and Installation" on page 409.
3. Thoroughly clean outside surface of transaxle.
4. Remove freewheel rod.



MX39909



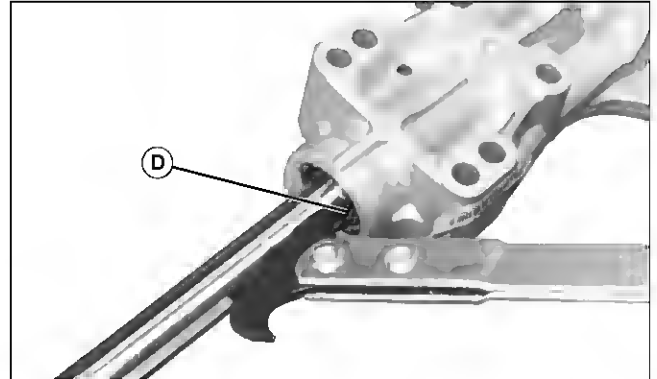
MX39910

5. Remove snap ring (A) securing input pulley (B), washer (C) and cooling fan to input shaft. Remove pulley and fan.

### Installation:

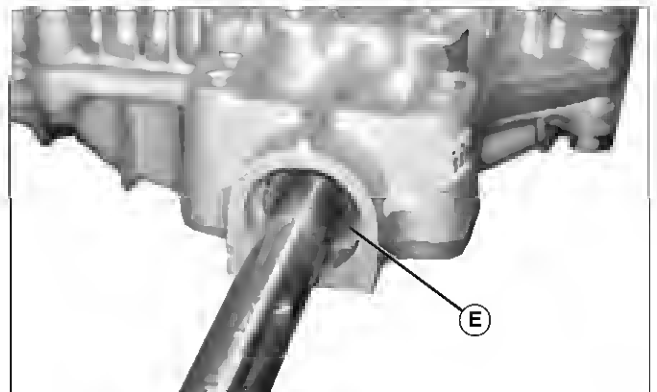
- Installation is in the reverse of removal.

## Axle Seal Replacement:



MX39911

1. Carefully pry out seal (D). Repeat for other axle.



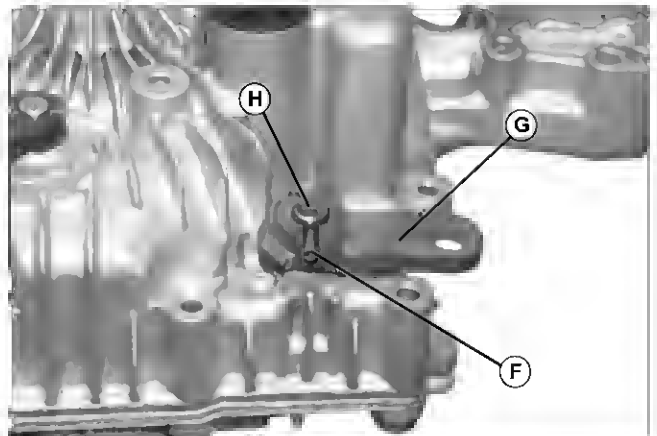
MX39912

2. Inspect bearings (E) for wear or damage.
3. Lightly grease axle and seal before installing new seal.

### Installation:

Installation is done in the reverse of removal.

### Brake Arm:



MX39913

1. Use pin punch and drive roll pin (F) from brake lever (G) and brake shaft (H).
2. Remove brake lever.

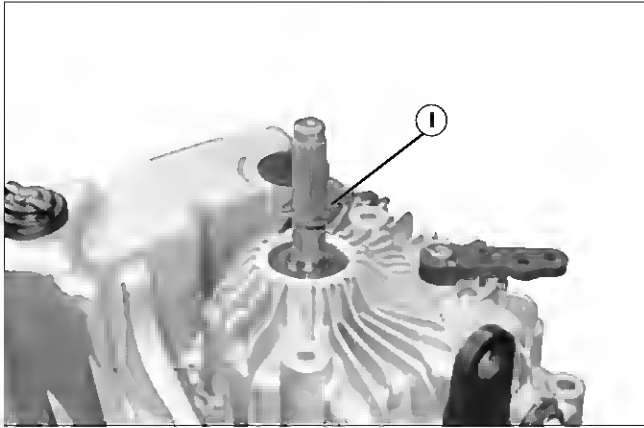
# POWER TRAIN - HYDROSTATIC REPAIR

## Installation:

Installation is done in the reverse of removal.

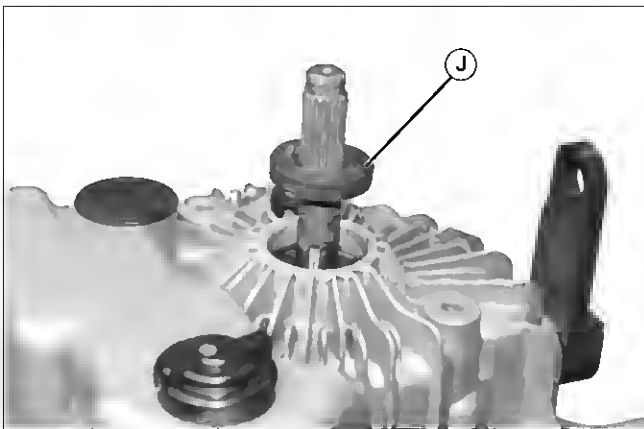
## Pump Shaft Seal Removal:

1. Remove snap ring, washer, and fan from input shaft.



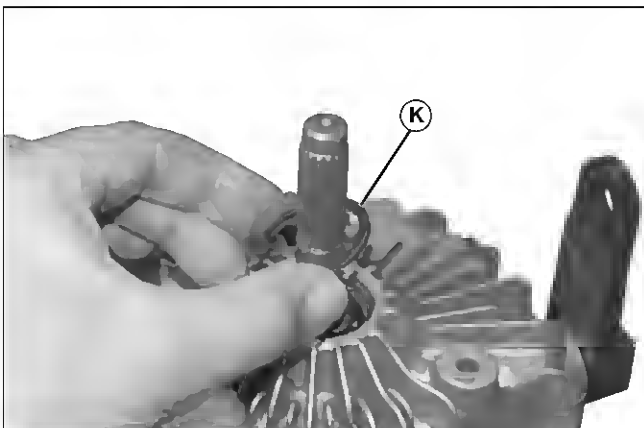
MX39914

2. Remove E-ring (I) in groove on input shaft.



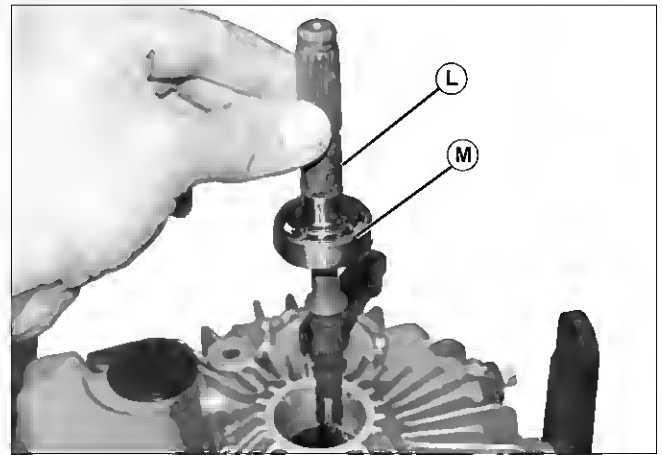
MX39915

3. Remove input shaft seal (J) from outside of upper case.



MX39916

4. Remove snap ring (K) from upper case.



MX39917

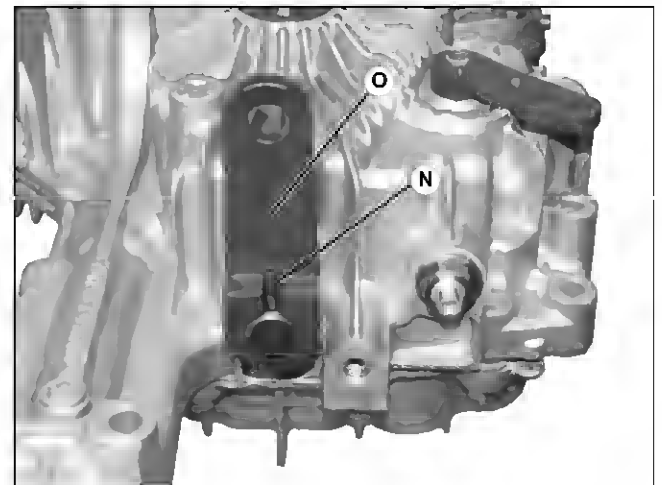
5. Remove input shaft (L) and bearing (M) from upper case.

6. Inspect bearing for wear or damage.

## Installation:

Installation is done in the reverse of removal.

## Control Arm Removal:



MX39918

1. Use pin punch to remove spring pin (N) securing control arm (O) to control shaft.

2. Inspect and replace parts as required.

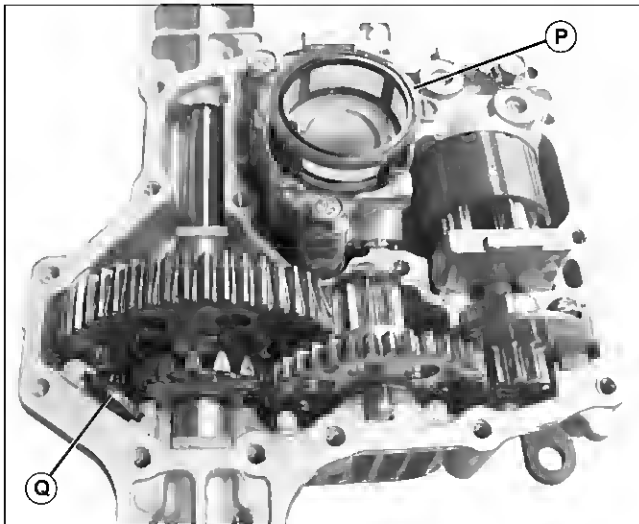
## Installation:

Installation is done in the reverse of removal.

## Oil Filter Replacement:

1. Remove bolts securing case halves.
2. Carefully pry case halves apart and drain transaxle oil.

# POWER TRAIN - HYDROSTATIC REPAIR



MX40017

3. Replace filter (P).
4. Remove, clean and install magnet (Q).
5. Clean gasket compound from case mating surfaces.

## Installation:

Installation is done in the reverse of removal.



MX40018

- Apply a thin bead of gasket material on mating surfaces.
- Mate case halves and install bolts. Tighten bolts to specification.

## Torque Specification:

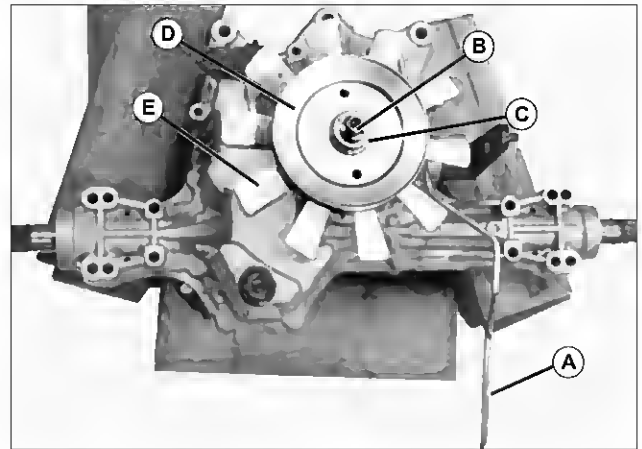
Case Half Bolts ..... 18 N•m (216 lb-in.)

## Transaxle Components Disassembly K58

**Note:** Obtain transaxle seal kit before service is performed. Do not reuse seals.

### Fan and Sheave Disassembly:

1. Remove transaxle from machine. See "Transaxle Removal and Installation - X304, X324" on page 405, or See "Transaxle Removal and Installation - X300, X320, X340" on page 404.
2. On X304 and X324 models remove transaxle carrier. See "Transaxle Carrier Removal and Installation" on page 409.
3. Thoroughly clean outside surface of transaxle.



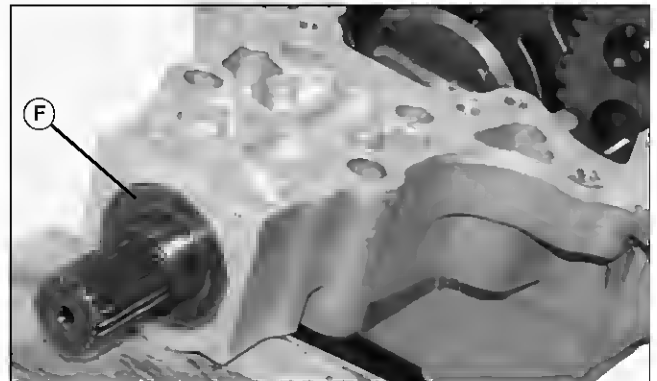
MX37489

4. Remove freewheel rod (A).
5. Remove lock nut (B) and washer (C) securing input pulley (D) and cooling fan (E) to input shaft. Remove pulley and fan.

## Installation:

Installation is done in the reverse of removal.

## Axle Seal Replacement:



MX37399

X324 / K58 shown.

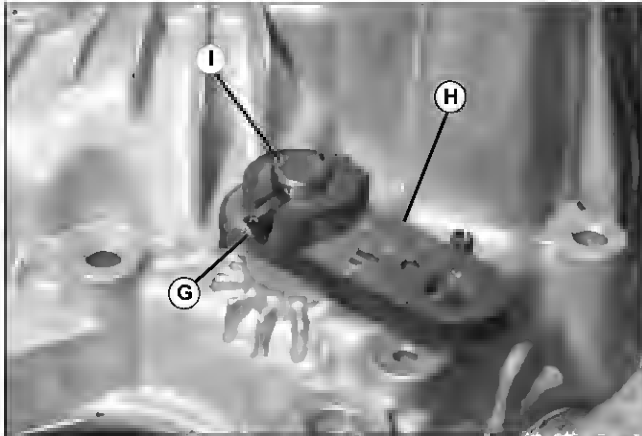
# POWER TRAIN - HYDROSTATIC REPAIR

1. Carefully pry out seal (F).
2. Inspect bearing for wear or damage.
3. Lightly grease axle and seal before installing new seal.

## Installation:

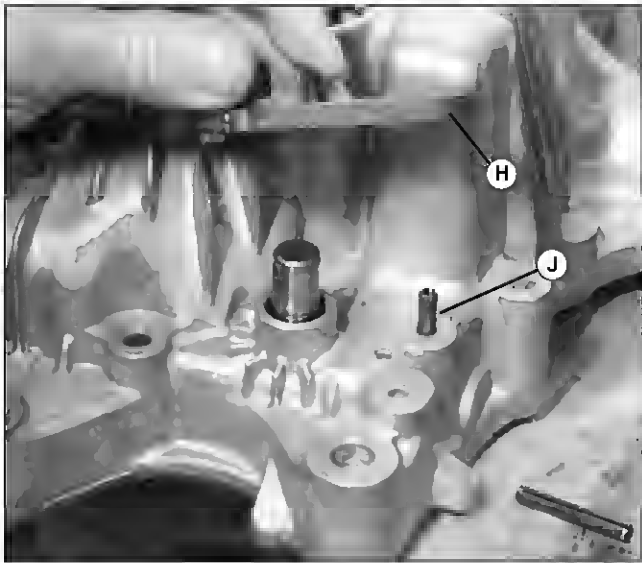
Installation is done in the reverse of removal.

## Brake Arm:



MX37566

1. Use pin punch and drive roll pin (G) from brake lever (H) and brake shaft (I).



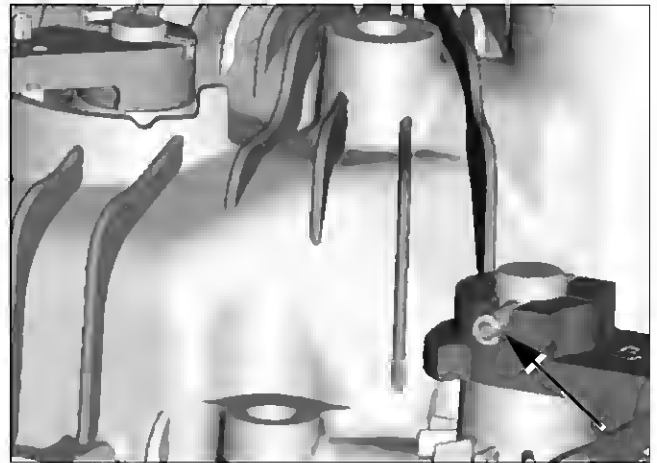
MX37567

2. Remove brake lever (H).
3. Inspect stop pin (J). Remove only if damaged.

## Installation:

Installation is done in the reverse of removal.

**Important: Avoid Damage! The split on the spring pin needs to be oriented toward the arm when installed.**

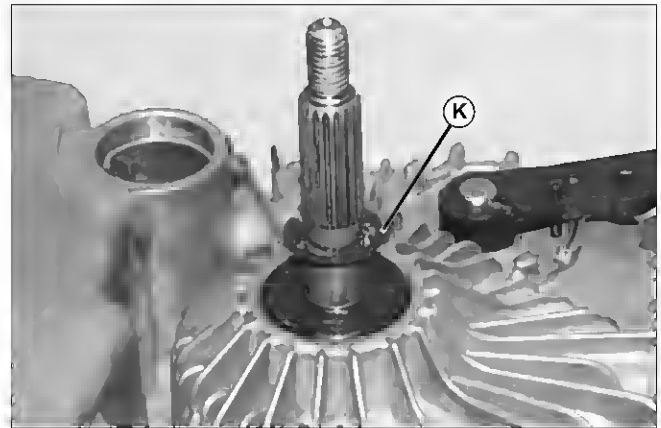


MX43788

## Spring Pin Orientation

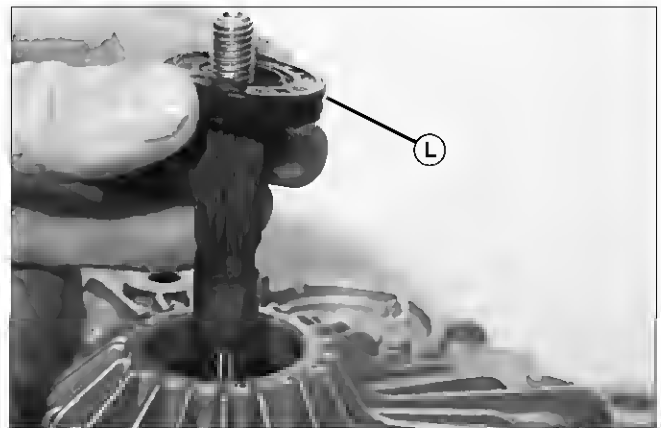
## Pump Shaft Seal Removal:

1. Remove fan and sheave from input shaft.



MX37620

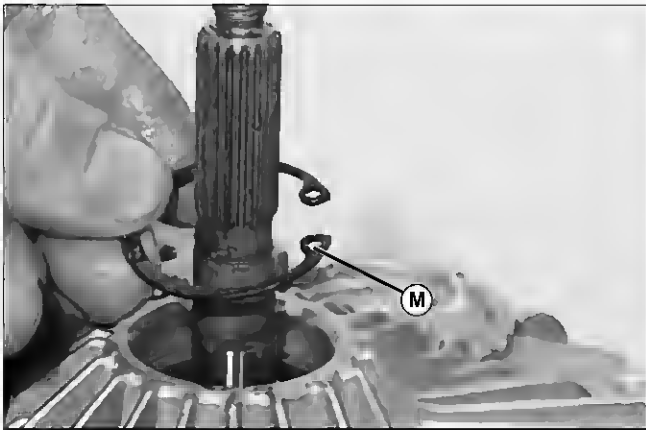
2. Remove E-ring (K) in groove on input shaft.



MX37577

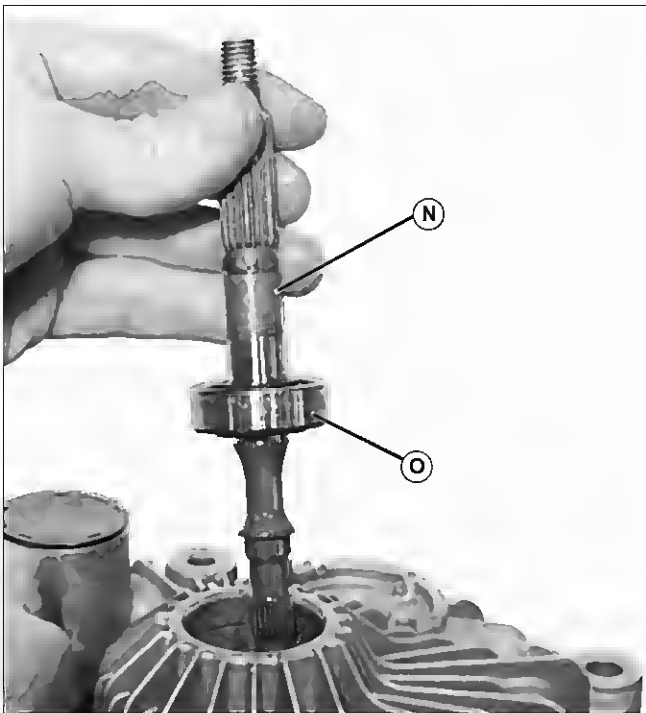
3. Remove input shaft seal (L) from outside of upper case.

# POWER TRAIN - HYDROSTATIC REPAIR



MX37578

4. Remove snap ring (M) from upper case.



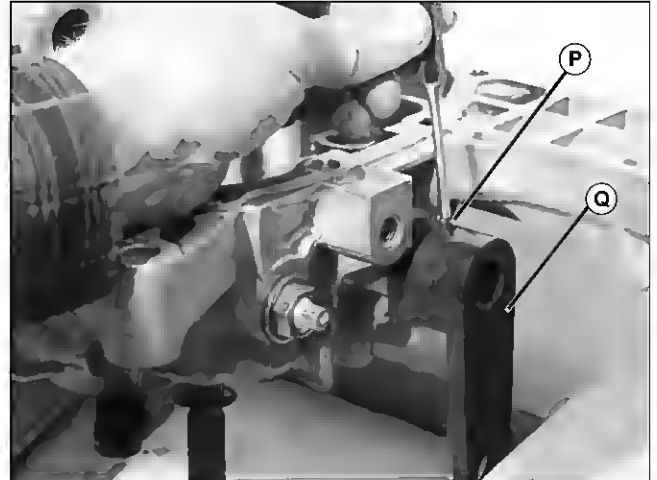
MX37579

5. Remove input shaft (N) and bearing (O) from upper case.
6. Inspect bearings for wear or damage.

## Installation:

Installation is done in the reverse of removal.

## Control Arm Removal:



MX37582

1. Use pin punch to remove spring pin (P) securing control arm (Q) to control shaft.
2. Inspect and replace parts as required.

## Installation:

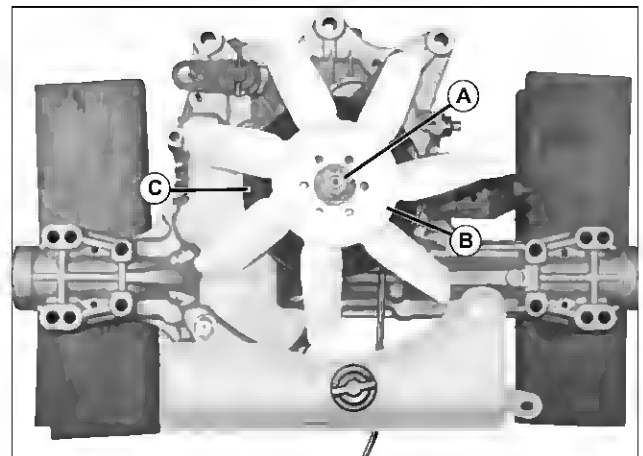
Installation is done in the reverse of removal.

## Transaxle Components Disassembly K58H

**Note:** Obtain transaxle seal kit before service is performed. Do not reuse seals.

## Fan and Sheave Disassembly:

1. Remove transaxle from machine. See "Transaxle Removal and Installation - X360" on page 407.
2. Thoroughly clean outside surface of transaxle.



MX40601

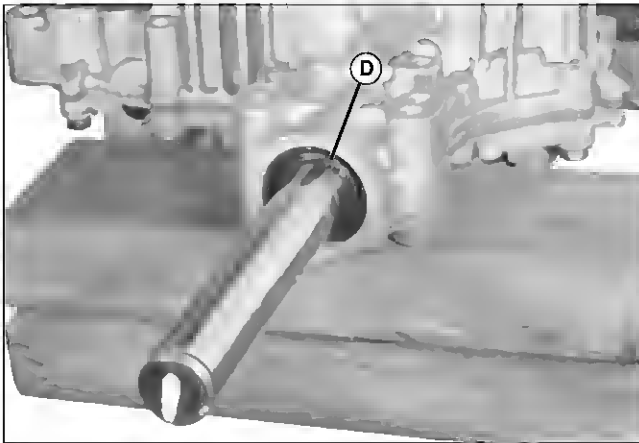
3. Remove lock nut (A), bushing and washer securing cooling fan (B) and input pulley (C) to input shaft. Remove pulley and fan.

# POWER TRAIN - HYDROSTATIC REPAIR

## Installation:

Installation is done in the reverse of removal.

## Axle Seal Replacement:



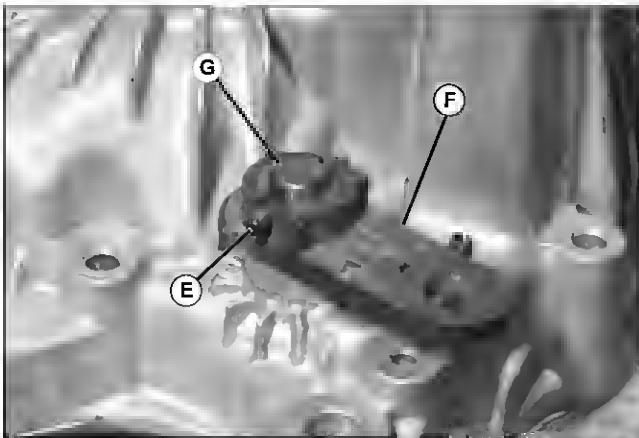
MX40602

1. Carefully pry out seal (D).
2. Inspect bearing for wear or damage.
3. Lightly grease axle and seal before installing new seal.

## Installation:

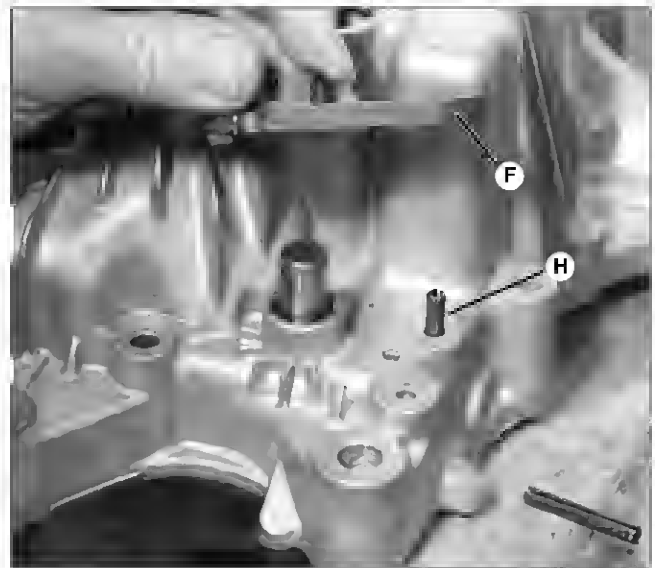
Installation is done in the reverse of removal.

## Brake Arm:



MX37566

1. Use pin punch and drive roll pin (E) from brake lever (F) and brake shaft (G).



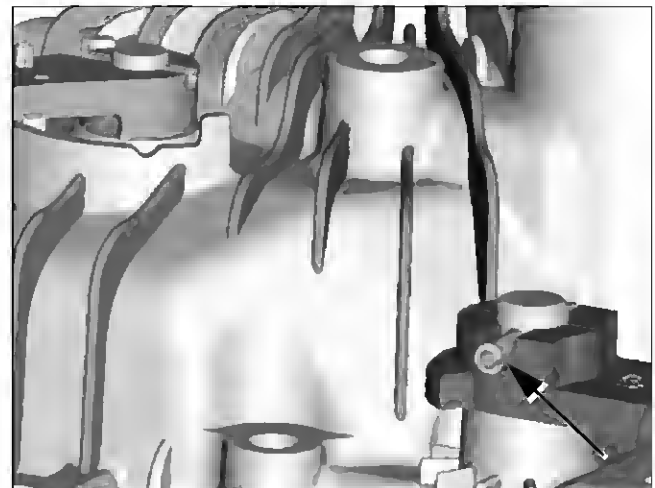
MX37567

2. Remove brake lever (F).
3. Inspect stop pin (H). Remove only if damaged.

## Installation:

Installation is done in the reverse of removal.

**Important: Avoid Damage! The split on the spring pin needs to be oriented toward the arm when installed.**



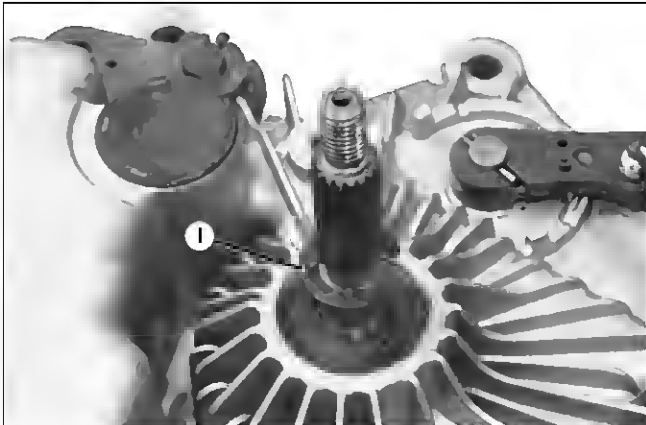
MX43788

## Spring Pin Orientation

# POWER TRAIN - HYDROSTATIC REPAIR

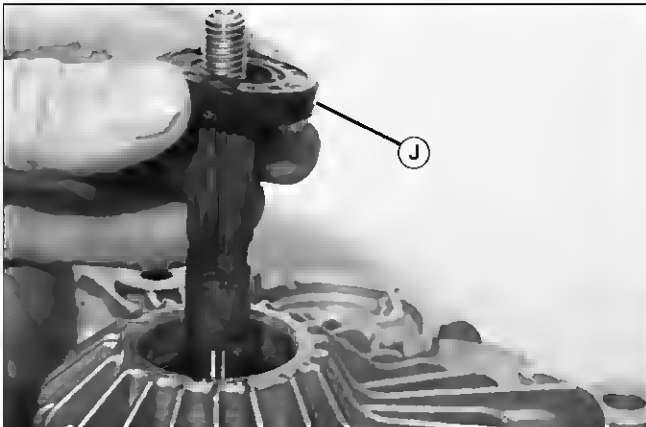
## Pump Shaft Seal Removal:

1. Remove fan and sheave from input shaft.



MX40603

2. Remove E-ring (I) from groove in input shaft.



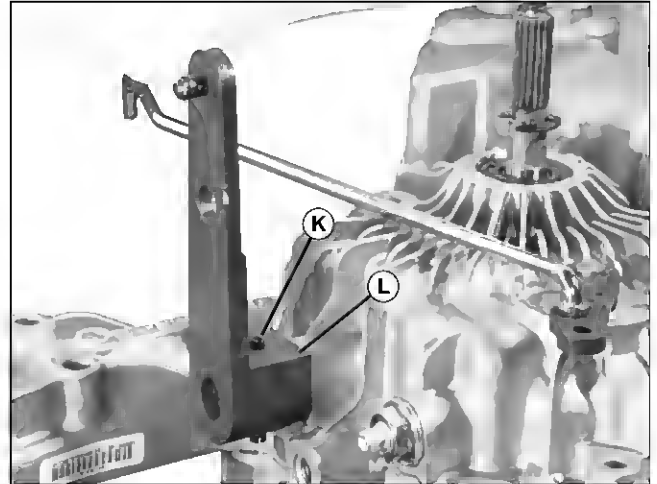
MX37577

3. Remove input shaft seal (J) from outside of upper case.

## Installation:

Installation is done in the reverse of removal.

## Control Arm Removal:



MX40604

1. Use pin punch to remove spring pin (K) securing control arm (L) to control shaft.
2. Inspect and replace parts as required.

## Installation:

Installation is done in the reverse of removal.

## Oil Filter Removal and Installation

For transaxle oil filter removal and installation, See "Changing Transaxle Oil and Filter (X360)" on page 429 of the Hydraulics section.



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# HYDRAULICS SPECIFICATIONS

## Specifications

## Tests and Adjustments Specifications

Mower Deck Lift Time (Oil Flow and Pressure Check) ..... 2 seconds at 2700 - 3000 engine rpm

## Repair Specifications

### Torque Specifications:

Draft Arm Retaining Cap Screw .....	110 N•m (80 lb-ft)
Hose Retainer Plate Cap Screws .....	31 N•m (23 lb-ft)
Hydraulic Line Connector Torque .....	24.4 N•m (18 lb-ft)
Hydraulic Hose Connector Torque .....	24.4 N•m (18 lb-ft)
Hydraulic Hose Fittings .....	24.4 N•m (18 lb-ft)
Lift Cylinder Lock Nut .....	40 N•m (30 lb-ft)
Steering Valve to Pedestal Cap Screws .....	65 N•m (48 lb-ft)

## Special Tools

### Special or Required Tools

Tool Name	Tool No.	Tool Use
	19 kg (42 lb) Weights	Use to check mower hydraulic lift oil flow and pressure

**Note:** Order tools according to information given in the US SERVICE-GARD™ Catalog or in the European Microfiche Tool Catalog (MTC).

## Special Materials

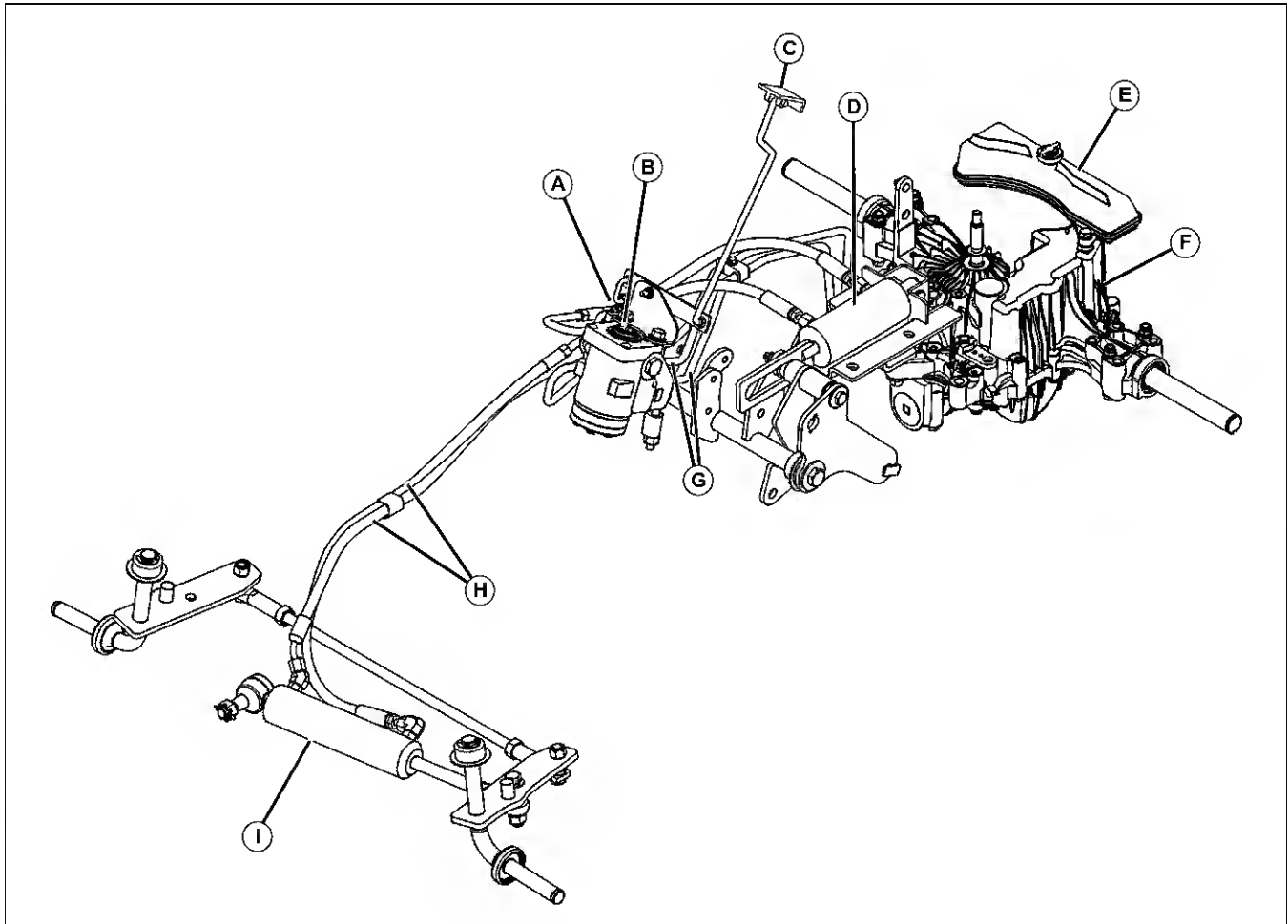
### Other Material

Part No.	Part Name	Part Use
J20D	John Deere Low Viscosity HY- GARD™	Hydraulic fluid

# HYDRAULICS COMPONENT LOCATION

## Component Location

### Hydraulic System Components

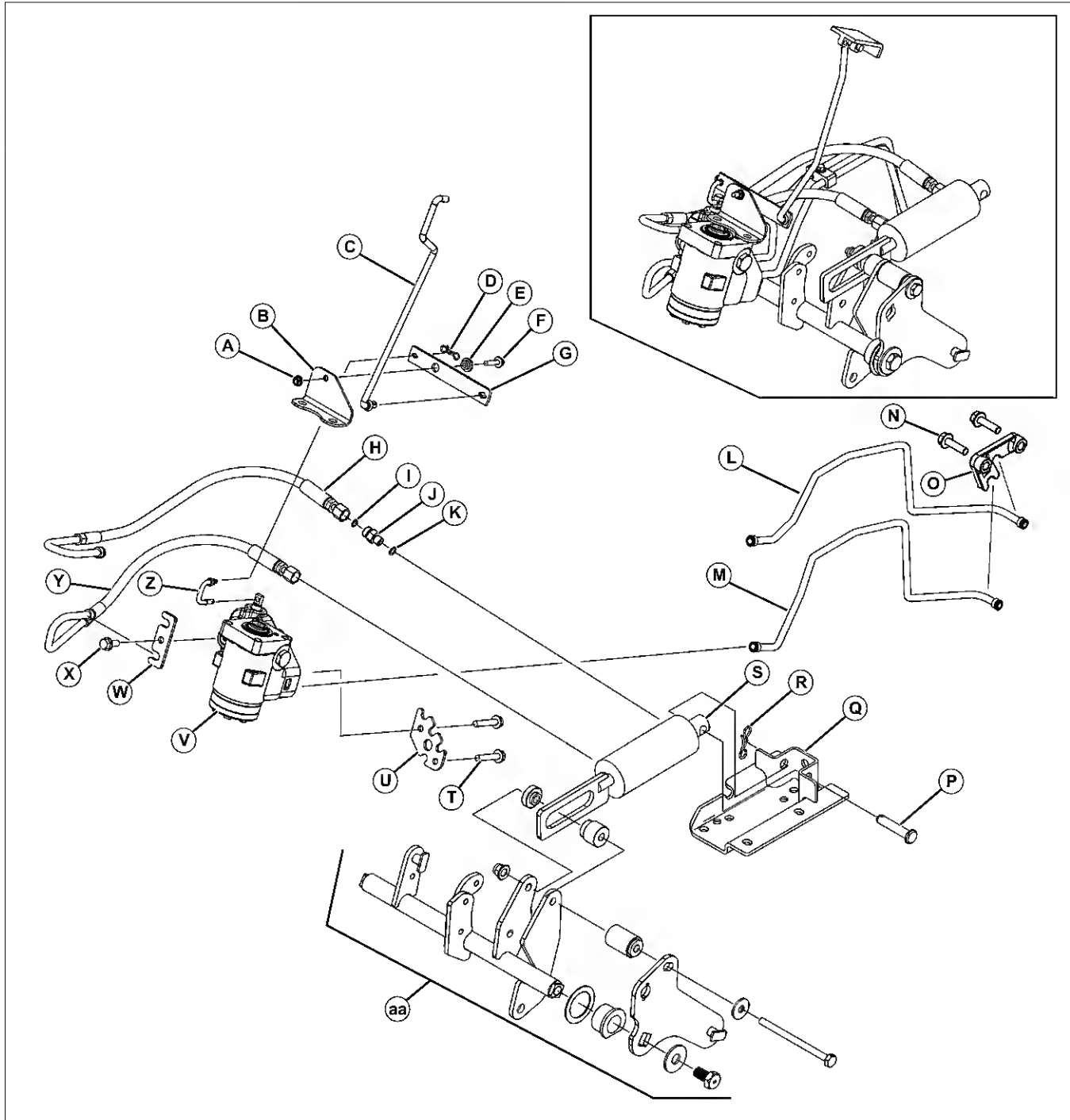


MX40440

- A- Lift Control Valve
- B- Steering Control Unit (SCU)
- C- Lift Control Lever
- D- Lift Cylinder
- E- Reservoir
- F- Hydrostatic Transmission
- G- Transmission to SCU Hydraulic Lines
- H- SCU to Steering Cylinder Hydraulic Lines
- I- Steering Cylinder

# HYDRAULICS COMPONENT LOCATION

## Hydraulic Lift Components



MX40441

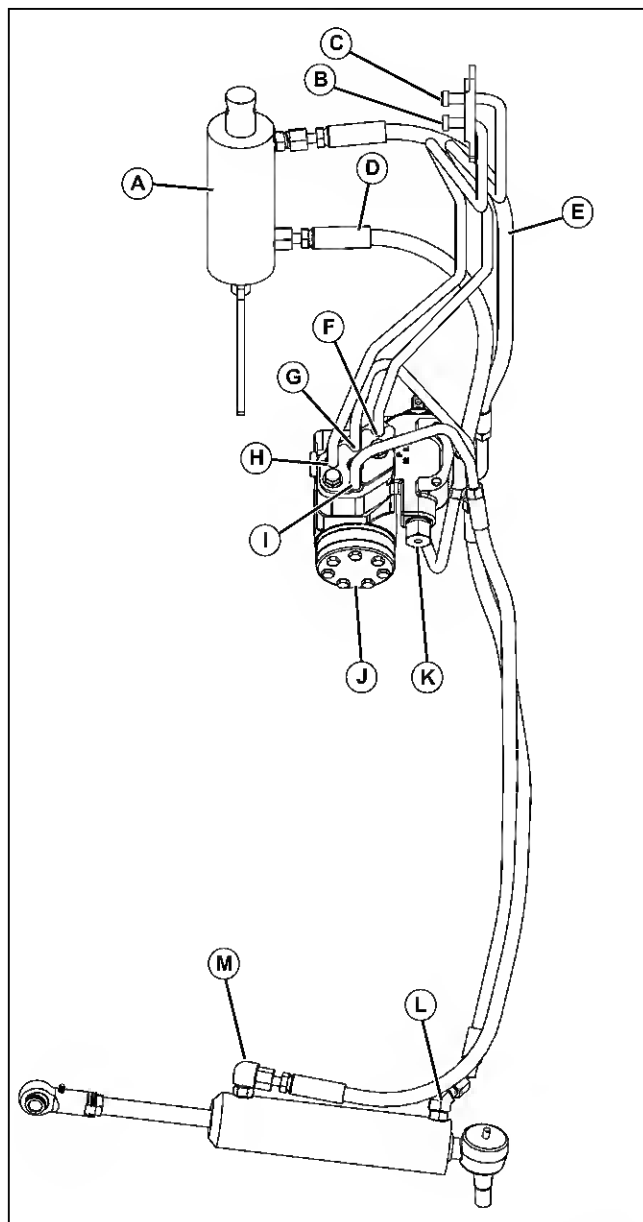
- A- Nut
- B- Bracket
- C- Lift Control Rod
- D- Spring Pin
- E- Bushing
- F- Bolt
- G- Pivot Bracket
- H- Hydraulic Hose

- I- O-Ring (2 used)
- J- Fitting (2 used)
- K- O-Ring (2 used)
- L- Hydraulic Line
- M- Hydraulic Line
- N- Cap Screw (2used)
- O- Clamp Bracket (to transaxle)
- P- Drilled Pin
- Q- Cylinder Bracket

# HYDRAULICS COMPONENT LOCATION

- R- Spring Pin
- S- Hydraulic Lift Cylinder
- T- Cap Screw (2 used)
- U- Clamp Bracket (to SCU)
- V- Steering Control Unit (SCU)
- W- Clamp Bracket (to SCU)
- X- Cap Screw
- Y- Hydraulic Hose
- Z- Link
- AA- Lift Components (See Attachments section)

## Hydraulic Lines



MX37124

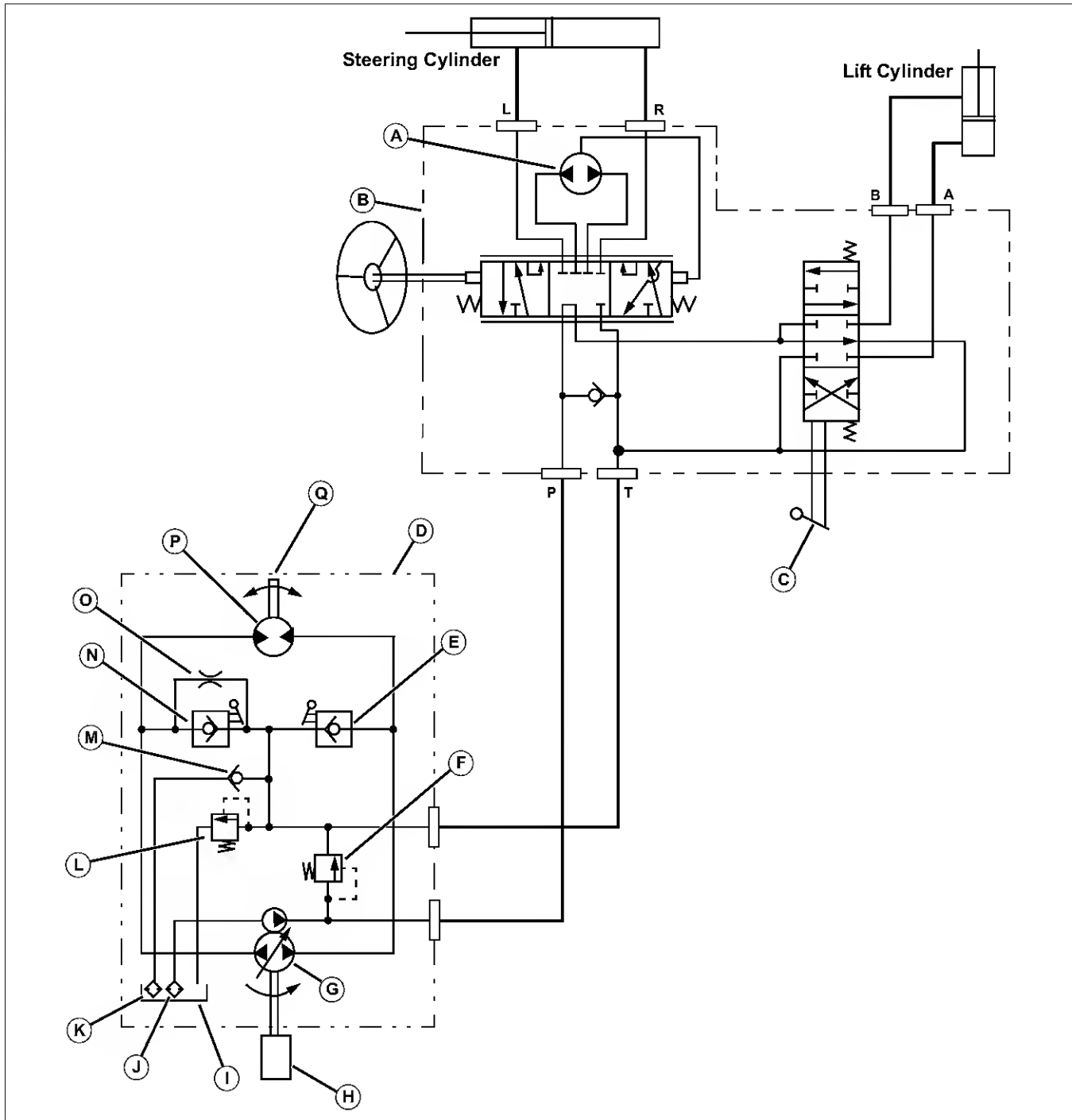
**Picture Note: Viewed from bottom/rear for clarity of**

### SCU line connections

- A- Lift Cylinder
- B- To Pressure Port of Transaxle
- C- To Return Port of Transaxle
- D- Lower Hydraulic Hose from Port "B" of SCU
- E- Raise Hydraulic Hose from Port "A" of SCU
- F- Port "T" of SCU to Return Port of Transaxle
- G- Port "L" of SCU to Piston End of Steering Cylinder
- H- Port "P" of SCU to Pressure Port of Transaxle
- I- Port "R" of SCU to Closed End of Steering Cylinder
- J- Steering Control Unit (SCU)
- K- Raise/Lower Control
- L- Steering Cylinder "R" Port
- M- Steering Cylinder "L" Port

# HYDRAULICS COMPONENT LOCATION

## Hydraulic Schematic



mif

A- Fluid Metering Section

B- Steering Control Unit (SCU)

C- Lift Control Valve

D- Transmission Case

E- Forward Check Valve

F- Implement Relief Valve

G- Variable Hydrostatic Pump

H- Input Shaft (Pump)

I- Reservoir

J- Internal Oil Filter

K- Bypass Valve Screen

L- Charge Pump Relief Valve

M- Charge Pump Bypass Valve

N- Reverse Check Valve

O- Fixed Orifice

P- Hydrostatic Drive Motor Rotating Group

Q- Output Shaft (Motor)

# HYDRAULICS THEORY OF OPERATION

## Theory of Operation

lifting the attachment capacity and in the specified time.

### Hydraulic Lift System Operation

#### Function:

To lift (or lower) the mower deck.

#### Theory of Operation:

**Note: Neutral Position Shown. Pressurized charge pump) oil is routed through the steering valve before reaching the lift system.**

Pressurized oil is supplied by the hydrostatic transmission and enters the control valve at Port "P" on the control valve housing (A).

#### Raise:

As the handle is moved to the RAISE position, linkage connected to the actuator causes the control valve spool (D) to change position (arrow). This routes the pressurized oil entering the control valve at Port "P" to port "A". The oil then passes to the closed end of the lift cylinder (B).

Oil returning from the lift cylinder enters the control valve at Port "B". Oil then is routed through the control valve spool, exiting the control valve through port "T", returning to the hydrostatic transmission case.

#### Lower:

As the handle is moved to the LOWER position, linkage connected to the actuator causes the control valve spool to change position. This allows pressurized oil entering the control valve at Port "P" to be routed through port "B" to the lower side of the lift cylinder.

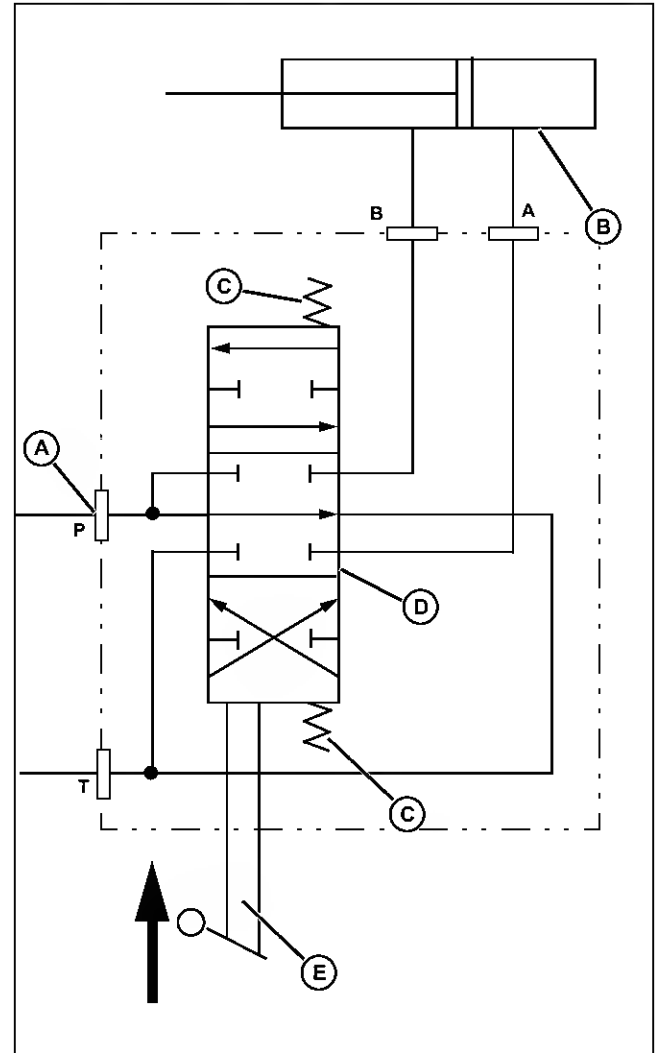
Oil returning from the lift cylinder enters the control valve at Port "A". Oil then is routed through the control valve spool, exiting the control valve through port "T", returning to the hydrostatic transmission case.

#### Neutral:

As the handle is released, the centering springs (C) return the control valve spool to the neutral position. Oil flow to/from the lift cylinder is then blocked, holding the cylinder in either the raised or lowered position.

#### Leak Down:

It is normal for the attachment lift to leak down over a period of time. This leak down can be as much as **5 mm (0.169 in.)** in a 5 minute period with the normal load attached. As the system ages, wear in the lift cylinder and the control valve will contribute to this leak down. If it is believed that a problem exist with the lift system, it should be verified with the "Hydraulic Lift Oil Flow and Pressure Check". This test will verify that the system is capable of



Picture Note: Shown in Neutral Position



# HYDRAULICS    DIAGNOSTICS

---

## Diagnostics

### Preliminary Hydraulic System Inspection

#### System Inspection:

##### Test Conditions:

- Engine off.
- Machine on hard level surface.

#### Hydraulic System - Engine Off (Preliminary Checks)

1. Hydraulic oil between marks on reservoir?

Yes: Go to next step.

No: Add John Deere Low Viscosity HY-GARD Transmission and Hydraulic Oil (J20D). Drain and replace.

2. Oil foamy, milky, metal particles noted, or discolored?

No: Go to next step.

Yes: Check for air leak and use of correct fluid.

Yes: Check for water in oil.

Yes: Check for mechanic failure.

Yes: Check for causes of overheating.

3. Oil leaking?

No: Go to next step.

Yes: Repair cause.

##### Test Conditions:

- Start engine.
- Operate ALL hydraulic functions.

#### Hydraulic System - Engine Running (Preliminary Checks)

1. Quick and positive steering response? Full right to full left with only slight effort? Steering wheel does not drift when driving in straight line?

Yes: Go to next step.

No: See the Steering section for steering system diagnosis.

2. Lift cylinder control lever: Implement should raise and lower. Holds implement up for a reasonable time (4 minutes) when in neutral?

Yes: Go to next step.

No: If lift cylinder rod leaked down 25.4 mm (1 in.) in the 1 - 2 minute range, check for cylinder leaks first, then proceed with tests.

3. Positive transmission speed control response: control forward, neutral, and reverse?

Yes: Go to next step.

No: See the Power Train section for transmission and speed control linkage diagnosis.

4. Hydraulic oil filter replaced at normal service intervals or replaced to verify filter is not restricted?

Yes: Go to next step.

No: Change hydraulic filter.

5. All hydraulic system checks normal?

Yes: Complaint not found and unable to duplicate complaint. Factory assistance for dealer is available through the Dealer Technical Assistance Center (DTAC).

Yes: Engine running preliminary checks completed.

### Noise From Transmission When Using Hydraulics

#### Test Conditions

- Machine parked on level surface.
- Key switch in OFF position.
- Parking brake ENGAGED.
- Transmission in NEUTRAL.
- Correct hydraulic oil level.

#### Noise From Transmission When Using Hydraulics

1. Is the hydraulic oil full, not contaminated and not foamy?

Yes: Go to next step.

No: Drain and or fill reservoir. Bleed air from system if foamy. See "Transaxle Bleeding (Except X360)" on page 393 in Power Train section.

2. Is the traction drive belt properly tensioned and not broken, frayed, glazed or stretched?

Yes: Go to next step.

No: Eliminate binding, replace faulty or damaged components or belt. See "Traction Drive Belt Removal and Installation (SN 085001-)" on page 396 in the Power Train section.

3. Do the hydraulic lines have sharp bends or restrictions?

Yes: Replace damaged lines.

No: Go to next step.

4. Are the charge pump inner or outer rotors and/or pump case worn or damaged<sup>1</sup>?

Yes: Replace worn or damaged charge pump components.

No: Go to next step.

5. Do the charge relief valves move freely, not dirty or damaged<sup>1</sup>?

Yes: Go to next step.

No: Clean or replace charge valve components.

6. Is the implement relief valve dirty, damaged or stuck open<sup>1</sup>?

Yes: Replace damaged components.

No: End of diagnosis.

## Excessive Attachment Drop With Control Valve In Neutral

### Test Conditions

- Machine parked on level surface.
- Key switch in OFF position.
- Parking brake ENGAGED.
- Transmission in NEUTRAL.

### Excessive Attachment Drop With Control Valve In Neutral

1. With the attachment raised, is the leak down approximately 5 mm (0.19 in.) in 5 minutes or more?

Yes: Go to next step.

No: Check control valve for leakage or replace cylinder.

2. Does the control valve have any leakage?

Yes: Repair or replace control valve.

No: End of diagnosis.

## Hydraulic Lift Slow Or No Lift Capacity

### Test Conditions

- Machine parked on level surface.
- Key switch in OFF position.
- Parking brake ENGAGED.
- Transmission in NEUTRAL.
- Correct hydraulic oil level.

### Hydraulic Lift Slow or No Lift Capacity

1. Is the hydraulic oil full, not contaminated and not foamy?

Yes: Go to next step.

No: Drain and or fill reservoir. Bleed air from system if foamy. See "Transaxle Bleeding (Except X360)" on page 393 in Power Train section. Run engine for 10 - 20 seconds to bleed air from system.

2. Has the mower deck lift speed been timed?

Yes: Go to next step.

No: See "Hydraulic Lift Oil Flow and Pressure Test" on page 428.

3. Is the traction drive belt properly tensioned and not broken, frayed, glazed, or stretched?

Yes: Go to next step.

No: Eliminate binding, replace faulty or damaged components or belt. See "Traction Drive Belt Removal and Installation (SN 085001-)" on page 396 in the Power Train section.

4. Do the hydraulic lines have sharp bends or restrictions?

Yes: Replace damaged lines.

No: Go to next step.

5. Does the lift cylinder have external leakage?

Yes: Replace cylinder.

No: Go to next step.

6. Does the control valve have any external or internal leakage?

Yes: Repair or replace control valve.

No: Go to next step.

7. Are the charge pump inner or outer rotors and/or pump case worn or damaged<sup>2</sup>?

---

1. Requires removal of transaxle from machine and disassembly.

2. Requires removal of transaxle from machine and disassembly.

# HYDRAULICS    DIAGNOSTICS

---

Yes: Replace worn or damaged charge pump components.

No: Go to next step.

8. Is the input shaft damaged or broken<sup>2</sup>?

Yes: Replace worn or damaged components.

No: Go to next step.

9. Do the charge relief valves move freely, not dirty or damaged<sup>2</sup>?

Yes: Go to next step.

No: Clean or replace charge valve components.

10. Is the implement relief valve dirty, damaged, or stuck open<sup>2</sup>?

Yes: Replace damaged components.

No: End of diagnosis.

No: Eliminate binding, replace faulty or damaged components or belt. See "Traction Drive Belt Removal and Installation (SN 085001-)" on page 396 in the Power Train section.

5. Does the lift cylinder have external or internal leakage?

Yes: Replace cylinder.

No: Go to next step.

6. Does the control valve have any external or internal leakage?

Yes: Repair or replace control valve.

No: Go to next step.

7. Is the lift lever/linkage binding, damaged, and returns to neutral when released?

Yes: Go to next step.

No: Repair or replace linkage.

8. Are the charge pump inner or outer rotors and/or pump case worn or damaged<sup>3</sup>?

Yes: Replace worn or damaged charge pump components.

No: Go to next step.

9. Is the input shaft damaged or broken<sup>3</sup>?

Yes: Replace worn or damaged components.

No: Go to next step.

10. Do the charge relief valves move freely, not dirty or damaged<sup>3</sup>?

Yes: Go to next step.

No: Clean or replace charge valve components.

11. Is the implement relief valve dirty, damaged, or stuck open<sup>3</sup>?

Yes: Replace damaged components.

No: End of diagnosis.

## Hydraulic Lift Will Not Work

### Test Conditions

- Machine parked on level surface.
- Key switch in OFF position.
- Parking brake ENGAGED.
- Transmission in NEUTRAL.
- Correct hydraulic oil level.

### Hydraulic Lift Will Not Work

1. Is the hydraulic oil full, not contaminated, and not foamy?

Yes: Go to next step.

No: Drain and or fill reservoir. Bleed air from system if foamy. See "Transaxle Bleeding (Except X360)" on page 393 in Power Train section. Run engine for 10 - 20 seconds to bleed air from system.

2. Has the mower deck lift speed been timed?

Yes: Go to next step.

No: See "Hydraulic Lift Oil Flow and Pressure Test" on page 428.

3. Are the internal/external filter(s) plugged?

Yes: Replace filter(s).

No: Go to next step.

4. Is the traction drive belt properly tensioned and not broken, frayed, glazed or stretched?

Yes: Go to next step.

---

3. Requires removal of transaxle from machine and disassembly.

# HYDRAULICS TESTS AND ADJUSTMENTS

## Tests and Adjustments

### Hydraulic Oil Warm-Up Procedure

#### Reason:

When making hydraulic tests the oil must be heated to normal operating temperature for the tests to be accurate.

#### Test Equipment:

- JDG282 Temperature Gauge

#### Procedure:

1. Install JDG282 Temperature Gauge on hydraulic line from transmission to steering control unit.
2. Lock park brake.

**Important: Avoid Damage! DO NOT overheat engine.**

3. Start engine and run at full throttle.
4. Move and hold hydraulic lever in implement raise position.
5. Periodically cycle all hydraulic functions to distribute heated oil.
6. Heat oil to operational temperature, **38 - 49° C (100 - 120° F)** typical.

### Hydraulic Lift Oil Flow and Pressure Test

#### Reason:

Check condition of charge pump and implement relief valve setting.

#### Equipment:

- Four 19 kg (42 lb) Weights

#### Procedure:

1. Set mower depth control knob and gauge wheels to **25 mm (1 in.)** position.
2. Lower mower deck to the ground.
3. Place two **19 kg (42 lb)** weights on top of mower deck on each side of machine (four total).
4. Lock parking brake.
5. With machine at room temperature, start and run engine at FAST idle for five minutes to warm up hydraulic oil.
6. Move throttle control lever to 3/4 throttle position (**2700 - 3000 rpm**).
7. Pull and hold lift lever back to raise mower deck to highest position. Record amount of time it takes to raise mower deck.

#### Results:

Lift system should raise mower deck within two seconds.

If lift time is not within specification:

- Replace internal transmission filter.
- Check traction drive belt for proper tension, wear or damage.
- Check hydraulic lines for sharp bends or restrictions. Replace damaged lines as necessary.
- Check lift cylinder for external or internal leakage. Replace cylinder if necessary.
- Check control valve for leakage. Repair or replace valve as necessary.
- Internal transmission damage. Remove and repair transmission. See the transaxle removal procedure in the Power Train section.

### Steering Valve and Cylinder Leakage Test

#### Reason:

To check the steering valve and cylinder for internal leakage.

#### Test Equipment:

- Torque Wrench
- JT03375, 9/16 - 18 M ORFS x 7/16 - 20 M 37° Fitting
- JT05484, 7/16 - 20 F 37° Cap

#### Procedure:

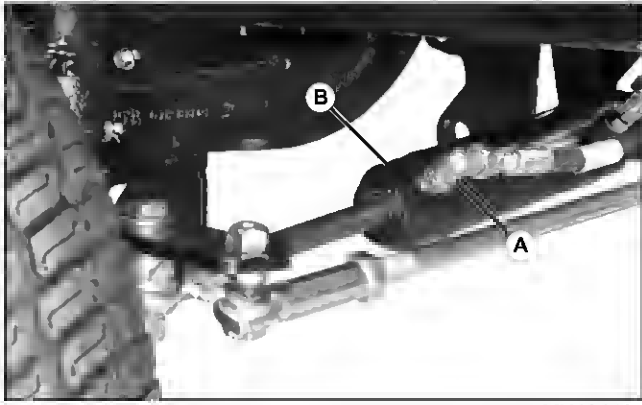


**Caution: Avoid Injury! Escaping fluid under pressure can penetrate the skin causing serious injury. Avoid the hazard by relieving pressure before disconnecting hydraulic or other lines. Tighten all connections before applying pressure. Search for leaks with a piece of cardboard. Protect hands and body from high pressure fluids.**

**If an accident occurs, see a doctor immediately. Any fluid injected into the skin must be surgically removed within a few hours or gangrene may result. Doctors unfamiliar with this type of injury may call the Deere & Company Medical Department in Moline, Illinois, or other knowledgeable medical source.**

1. Remove steering wheel center cover.
2. Turn wheels for a complete right turn.

# HYDRAULICS REPAIR



MX40442

3. Disconnect return hose (A) from the steering cylinder (B).
4. Cap return hose with JT03375 Fitting and JT05484 Cap.
5. Heat hydraulic oil to approximately **43°C (110°F)**. See "Hydraulic Oil Warm-Up Procedure" on page 428.
6. Run engine at fast idle.
7. Using a torque wrench on steering wheel nut, turn steering wheel right with a constant torque of **6.8 N•m (60 lb-in.)**.
8. Observe the number of rotations of the steering wheel that occurs in one minute. Also observe leakage from cylinder return connector. Compare results to specifications.
9. Reinstall hose and tighten to **24.4 N•m (18 lb-ft)**.

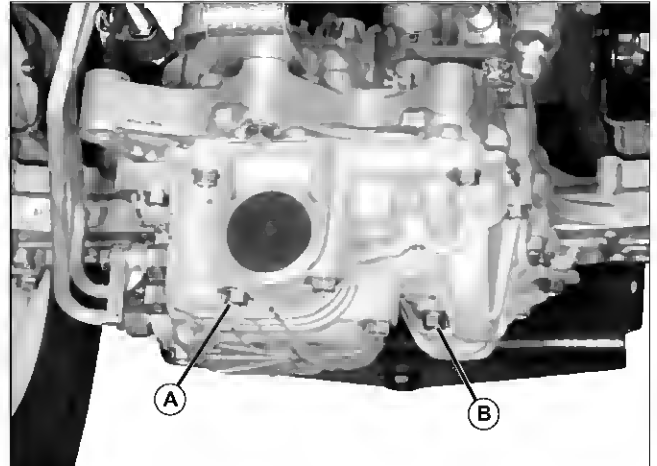
## Results:

- If steering wheel rpm is more than 4 rpm, and there is leakage (steady stream) from the cylinder return connector, the steering cylinder is leaking. Replace cylinder. Repeat test.
- If steering wheel rpm is still more than 4 rpm, repair or replace steering valve.

## Repair

### Changing Transaxle Oil and Filter (X360)

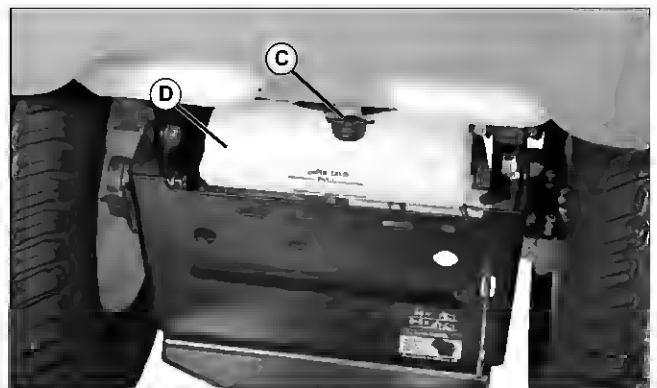
1. Park machine safely with park brake locked. See "Park Machine Safely" in the Safety section.
2. Remove mower deck. See Mower Deck Removal and Installation for the appropriate deck in the Attachments section.



MX40431

3. Place drain pan under drain plugs (A) and (B). Remove plugs.

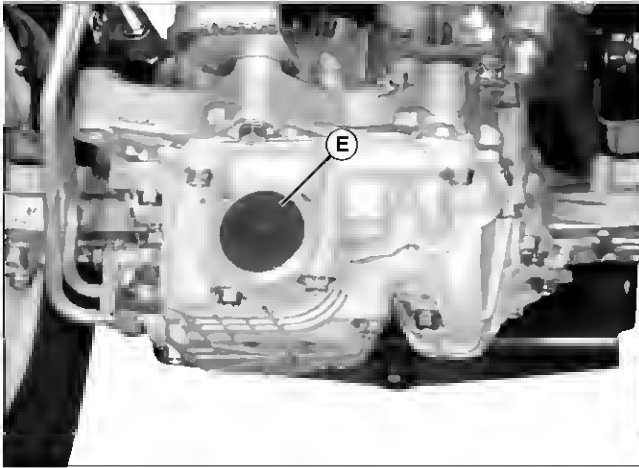
**Important: Avoid Damage! Contamination can damage the hydraulic system. Clean thoroughly around reservoir fill cap before proceeding.**



MX40430

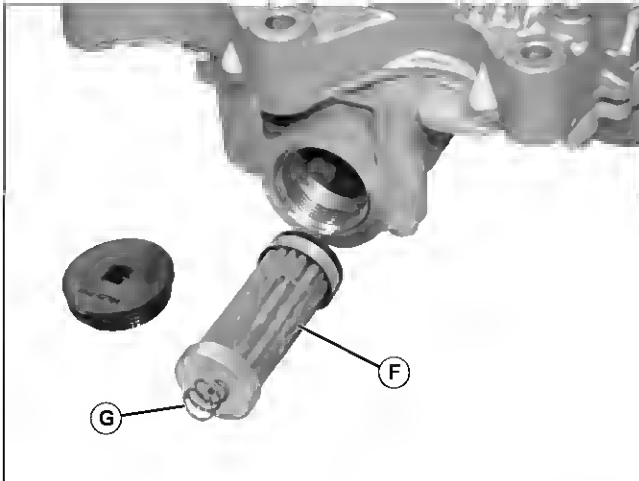
4. Clean area around transaxle fill cap (C) on transaxle oil reservoir (D).
5. Remove fill cap to improve drainage. Allow to drain completely.
6. Replace transaxle hydraulic filter:

# HYDRAULICS REPAIR



MX40431

- a. Remove cap (E) from front side of transaxle using a 3/8-inch ratchet.



MX40393

- b. Remove and discard transaxle filter (G).
- c. Install new filter with spring (G) towards access cap. Install and tighten cap.
7. Install and tighten transaxle drain plugs.
8. Add approximately 2.8 L (3.0 qt) John Deere Low Viscosity HY-GARD (J20D) to transaxle reservoir (D) until oil level is at FULL mark. Install reservoir cap.
9. Start engine.
10. Check for leaks around drain plugs and hydraulic filter.
11. Operate machine forward and in reverse several times.
12. Park machine safely with park brake locked. See "Park Machine Safely" in the Safety section.
13. Wait at least 3 minutes for hydraulic oil to cool.
14. Check oil level in reservoir. Add oil to reservoir if necessary.

## Hydraulic Lift Cylinder Removal and Installation

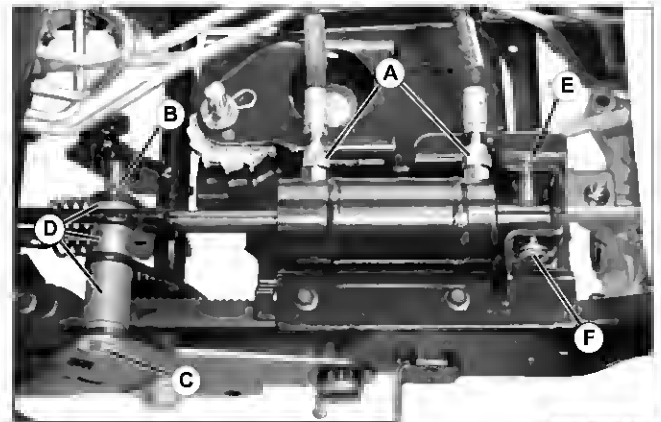


**Caution: Avoid Injury! Escaping fluid under pressure can penetrate the skin causing serious injury. Avoid the hazard by relieving pressure before disconnecting hydraulic or other lines. Tighten all connections before applying pressure. Search for leaks with a piece of cardboard. Protect hands and body from high pressure fluids.**

**If an accident occurs, see a doctor immediately. Any fluid injected into the skin must be removed within a few hours or gangrene may result. Doctors unfamiliar with this type of injury may call Deere & Company Medical Department in Moline, Illinois, or other knowledgeable medical source.**

### Removal:

1. Park machine safely with park brake locked. See "Park Machine Safely" in the Safety section.
2. Remove mower deck. See Mower Deck Removal and Installation for the appropriate deck in the Attachments section.
3. Open or remove hood.
4. Disconnect negative (-) battery cable.
5. Remove fender deck. See "Fenderdeck Removal and Installation" on page 566 in Miscellaneous section.



MX40443

6. Disconnect hydraulic hoses (A) from lift cylinder. Cap all connections to prevent contamination.
7. Remove flange nut (B), cap screw (C) and washer, and spacers (D).
8. Remove spring pin (E) and drilled pin (F).
9. Remove lift cylinder.

# HYDRAULICS REPAIR

## Installation:

Installation is done in reverse order of removal.

## Specifications:

Hydraulic Hose Fittings ..... 24.4 N•m (18 lb-ft)

Lift Cylinder Lock Nut ..... 40 N•m (30 lb-ft)

## Steering Control Unit (SCU) Removal and Installation

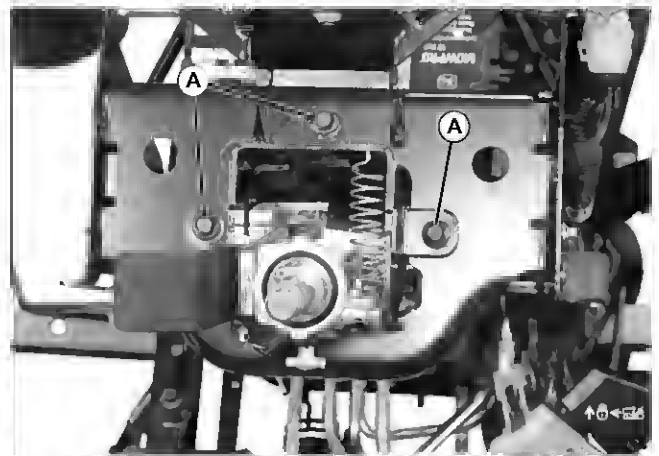


**Caution: Avoid Injury!** Escaping fluid under pressure can penetrate the skin causing serious injury. Avoid the hazard by relieving pressure before disconnecting hydraulic or other lines. Tighten all connections before applying pressure. Search for leaks with a piece of cardboard. Protect hands and body from high pressure fluids.

If an accident occurs, see a doctor immediately. Any fluid injected into the skin must be removed within a few hours or gangrene may result. Doctors unfamiliar with this type of injury may call Deere & Company Medical Department in Moline, Illinois, or other knowledgeable medical source.

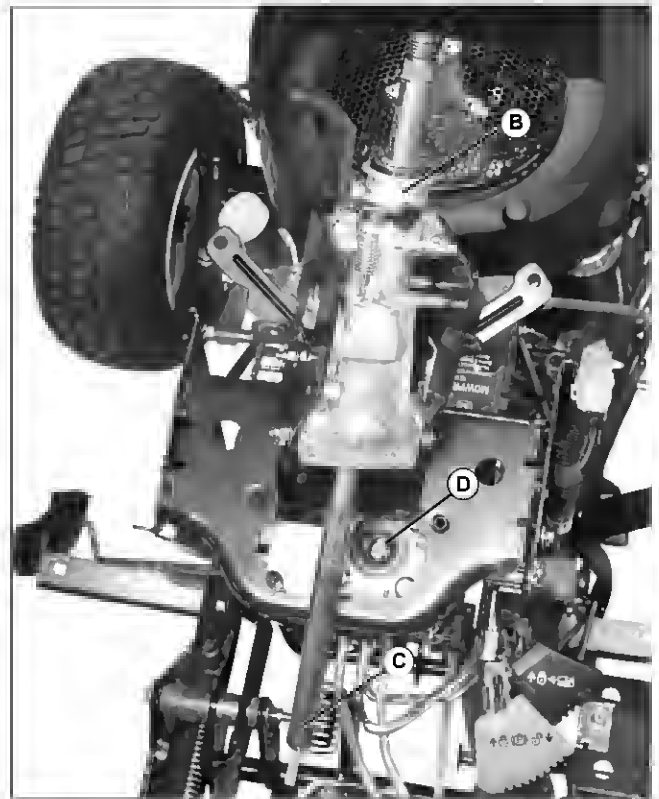
## Removal:

1. Park machine safely with park brake locked. See "Park Machine Safely" in the Safety section.
2. Remove mower deck. See Mower Deck Removal and Installation for the appropriate deck in the Attachments section.
3. Remove hood.
4. Disconnect negative (-) battery cable.
5. Remove steering wheel. See "Steering Wheel Removal and Installation" on page 563 in Miscellaneous section.
6. Remove the control console upper, lower and center panels. See "Control Panel Removal and Installation" on page 563 in the Miscellaneous section.
7. Remove fender deck. See "Fenderdeck Removal and Installation" on page 566 in the Miscellaneous section.



MX40444

8. Remove bolts (A) securing steering tilt mechanism to frame.



MX40445

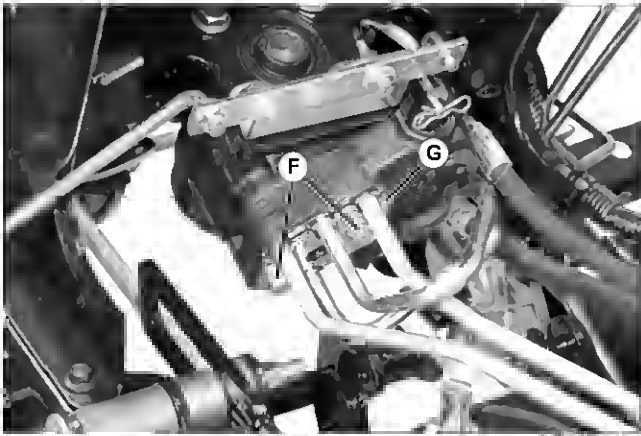
9. Remove tilt steering assembly (B) from top of steering column. Bottom of steering shaft (C) is a slip fit in top of steering control unit (D).

**Note: Capacity of the transaxle is approximately 2.8 L (3.0 qt). Have a suitable container ready before removing drain plugs.**

10. Drain transaxle oil into a suitable container. See "Changing Transaxle Oil and Filter (X360)" on page 429.

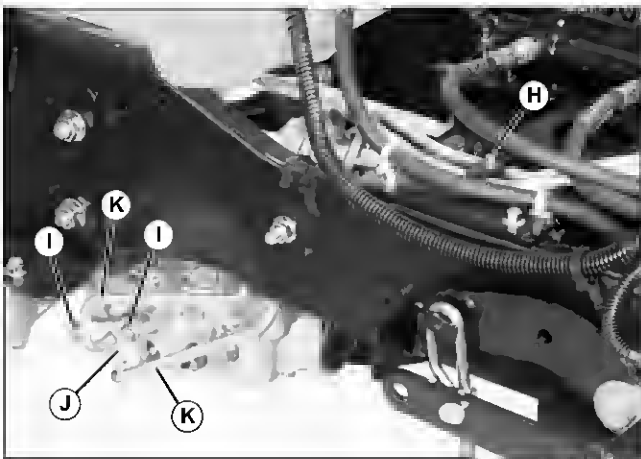
**Note: Mark hydraulic lines and hoses as needed to ensure correct assembly.**

# HYDRAULICS REPAIR



MX40446

11. Remove screws (F) and hydraulic line retainer (G) on steering control unit.



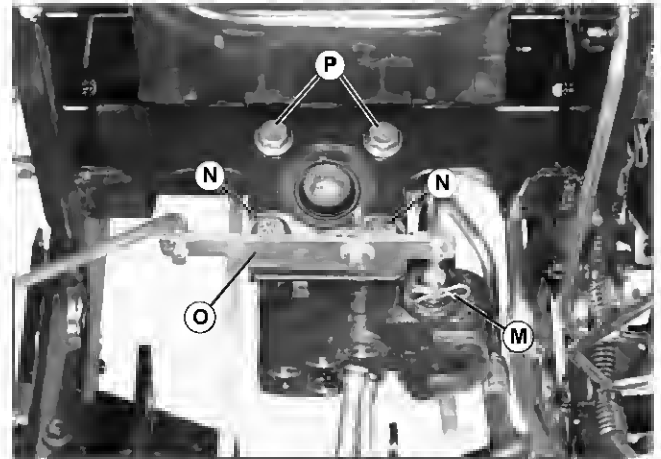
MX40447

12. Remove screw (H) and tube clamp retaining hydraulic lines to frame.

13. Remove two screws (I) and tube support (J) that secure hydraulic lines to transaxle.

14. Pull supply and return hydraulic lines (K) from ports in transaxle.

15. Pull hydraulic lines from ports in steering control unit, where retaining clamp was removed earlier.

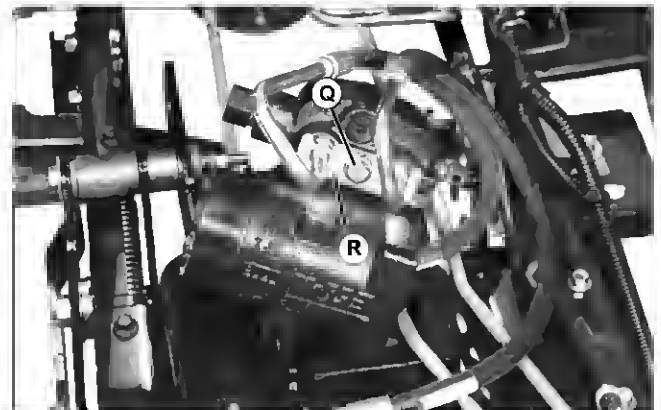


MX40448

16. Remove the spring pin (M).

17. Remove the two rear mounting cap screws (N) and remove the valve linkage and bracket assembly (O).

18. Remove the two front mounting cap screws (P) and carefully remove the steering control unit from the steering pedestal and position with access to the lift cylinder hydraulic line retaining plate.



MX40530

19. Remove the cap screw (Q) and hydraulic lines retaining plate (R).

20. Remove the hydraulic lines and remove the steering control unit to a clean work area.

## Installation:

Installation is done in reverse order of removal.

- Apply a light coat of grease on the o-rings on the hydraulic lines before installing them into the steering control unit.

## Specifications:

Retaining Plate Cap Screws . . . . . 31.2 N•m (23 lb-ft)

Steering Control Unit Mounting Cap Screws 65 N•m (48 lb-ft)

Hydraulic Hose Fittings . . . . . 24.4 N•m (18 lb-ft)



# HYDRAULICS REPAIR

## Steering Control Unit (SCU) Disassembly and Assembly

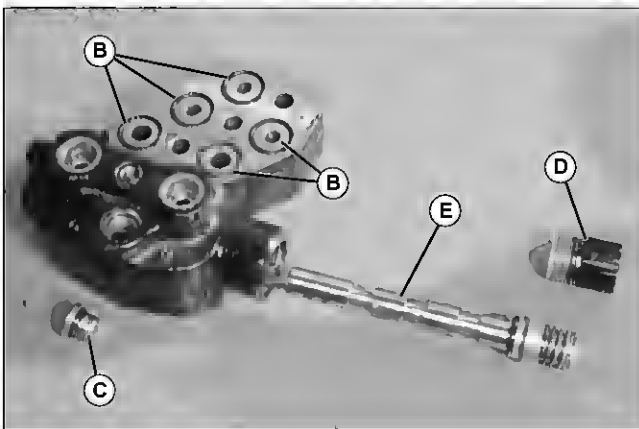
### Disassembly:

1. Thoroughly clean the outside of valve assembly.



MX36919

2. Remove the socket head cap screw (A) securing the valve body to the steering control unit. Separate the two sections.

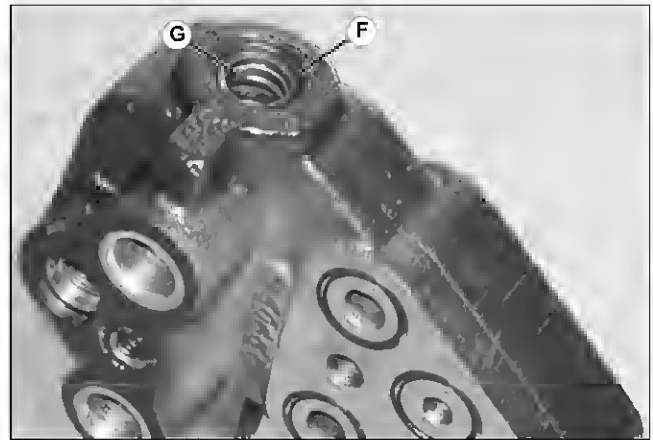


MX36920

3. Remove the o-rings (B).
4. Remove the port plug (C) and inspect the o-ring.

**Note:** Spool and valve body are a matched set, replace entire valve assembly if any parts are damaged or worn.

5. Remove the valve spool cap (D) and carefully remove the valve spool (E) from the valve body.



MX36922

6. Remove the dust seal (F) and internal o-ring (G) from the valve bore.
7. Inspect all parts for wear or damage. Replace parts if necessary.

**Important: Avoid Damage! Absolute cleanliness is essential when working on valve. Contamination can result in serious damage or inadequate operation.**

**DO NOT** use shop towels or rags to dry clean parts. Lint will clog passages in hydrostatic system and cause damage.

Reduce compressed air to less than 210 kPa (2 bar) (30 psi) when using for cleaning purposes. Clear area of bystanders, guard against flying chips, and wear personal protection equipment including eye protection.

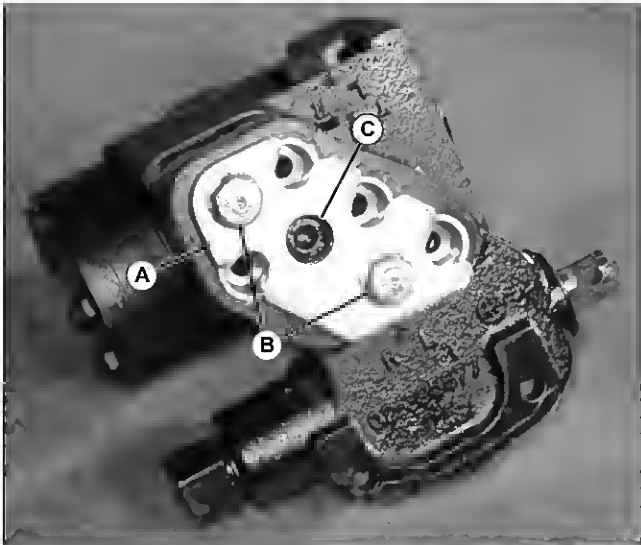
8. Clean all parts with solvent and blow dry with compressed air.

### Assembly:

Assembly is done in reverse order of disassembly.

**Important: Avoid Damage! Always use new O-rings. Damaged or used parts will leak.**

1. Lubricate O-rings with petroleum jelly during assembly.
2. Apply clean hydraulic oil to all internal parts during assembly.



MX36921

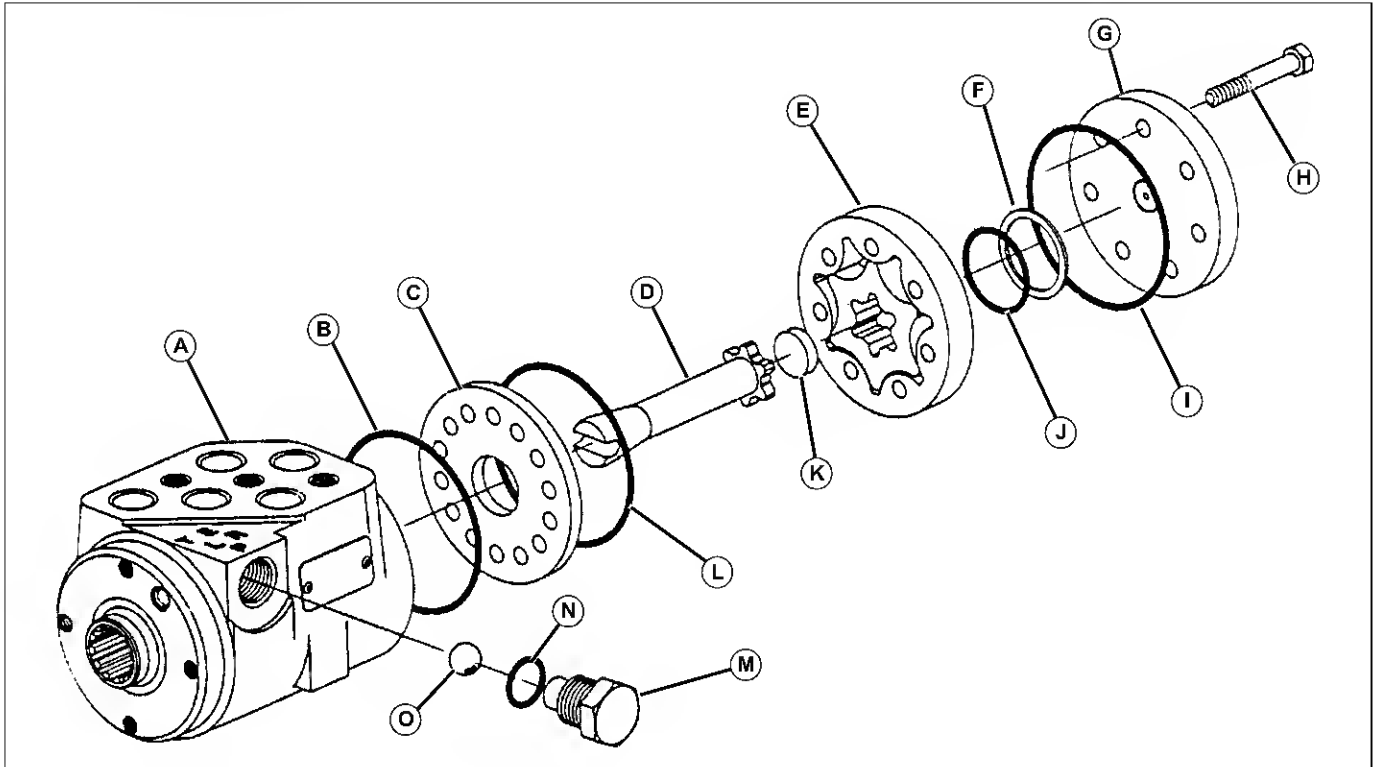
3. Install the retainer plate (A) and the two cap screws (B) until finger tight.
4. Install the socket head cap screw (C) and tighten to specification.
5. Remove retainer plate for installation.

**Specification:**

**Retainer Plate Cap Screws . . . . . 30 N•m (22 lb-ft)**

# HYDRAULICS REPAIR

## Steering Valve Disassembly and Assembly



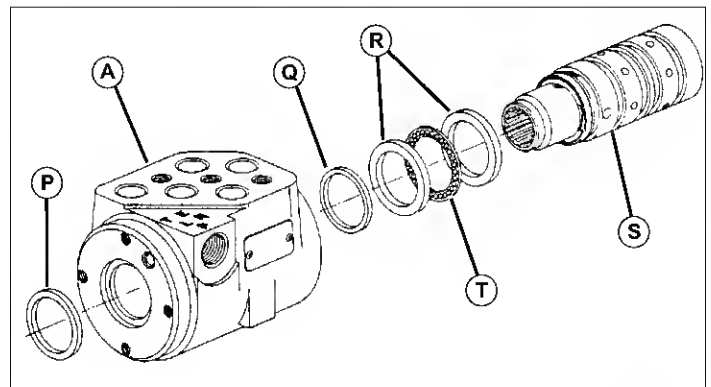
M81128

- A- Steering Valve Housing
- B- O-Ring
- C- Wear Plate
- D- Drive Shaft
- E- Gerotor Set
- F- Seal Ring
- G- End Cover
- H- Cap Screw
- I- O-Ring
- J- O-Ring
- K- Spacer
- L- O-Ring
- M- Plug
- N- O-Ring
- O- Check Ball

1. Remove cap screws (H) to remove components from housing.

- End Cover (G)
- O-Ring (I)
- Seal Ring (F)
- O-Ring (J)
- Spacer (K)
- Gerotor Set (E)
- O-Ring (L)

- Drive Shaft (D)
  - Wear Plate (C)
  - O-Ring (B)
2. Remove manual steering check components:
- Plug (M)
  - O-ring (N)
  - Check ball (O)



M81129

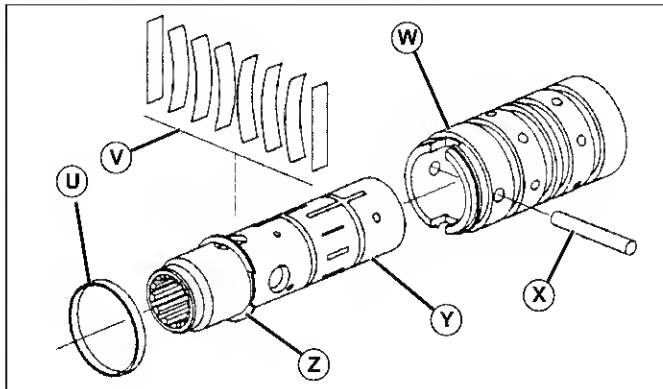
3. Pull spool and sleeve assembly (S) from steering valve housing (A).

4. Remove quad seal (Q), thrust bearing race (R), and thrust bearing (T) components.

# HYDRAULICS REPAIR

**Important: Avoid Damage! Use care not to damage seal bore during removal.**

5. Pry dust seal (P) from housing.



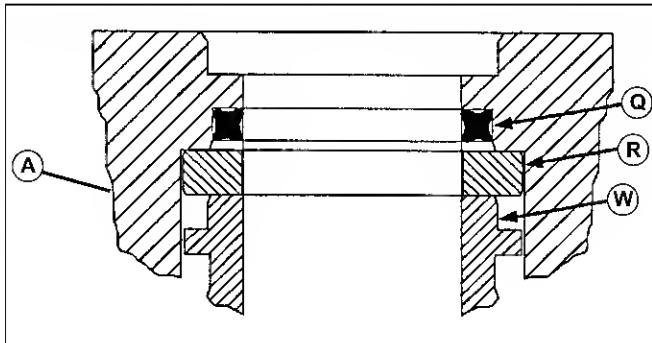
M81130

6. Remove pin (X) to separate sleeve (W) from spool (Y).  
7. Remove retaining collar (U).



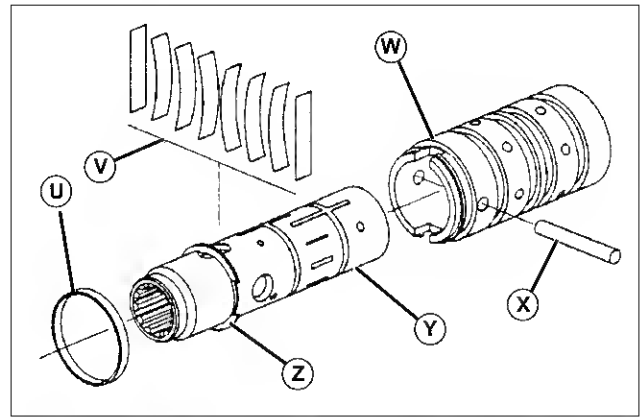
**Caution: Avoid Injury! Use care when removing springs because springs (V) are under tension.**

8. Remove retaining ring (Z).  
9. Inspect all machined mating surfaces for scratches or burrs. Clean all parts in clean solvent and air dry.



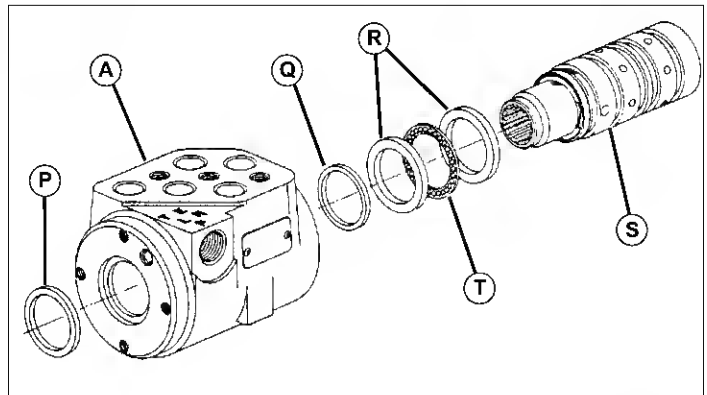
M81131ae

10. Install one bearing race (R) and sleeve (W) into valve housing (A).  
11. While holding sleeve and bearing race tightly into housing, install quad seal (Q) into groove between bearing race and housing. Make sure the seal is not twisted.  
12. Remove sleeve and bearing race.



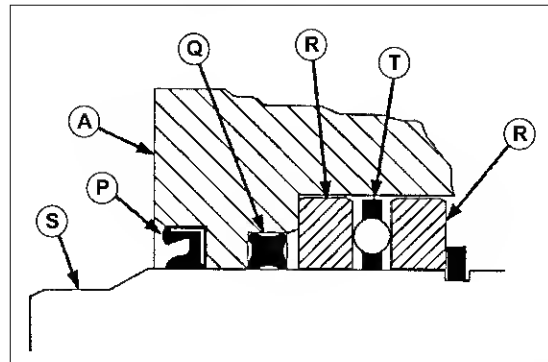
M81130

13. Install retaining ring (Z).  
14. Install two flat leaves of springs (V) in slot of spool (Y). Then install curved leaves between flat leaves, three at a time. Install retaining collar (U) over springs.  
15. Apply clean hydraulic oil to spool and install spool in sleeve (W). Springs must fit into notches of sleeve.  
16. Install pin (X).



M81129

17. Install dust seal (P) with open side of seal away from housing (A). Use a disk driver to push seal to bottom of bore. Apply petroleum jelly to seal lips and quad seal (Q).



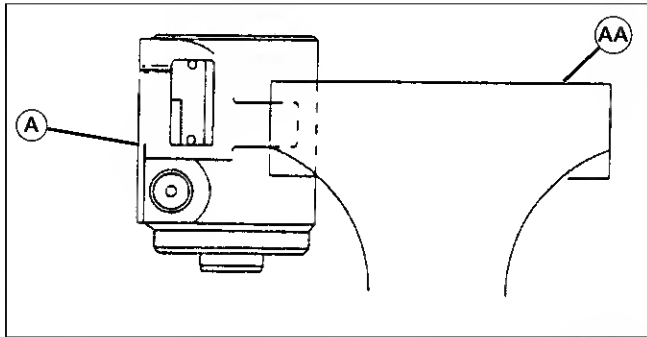
M81133ae

18. Install thrust bearing race (R), thrust bearing (T), and second thrust bearing race (R) components.

## HYDRAULICS REPAIR

19. Apply clean hydraulic oil to spool and sleeve assembly (S). Carefully install assembly into housing (A) so not to damage seals.

**Important: Avoid Damage! Tighten vise only enough to hold housing or damage may occur to housing and sleeve.**



M81134

20. Put housing (A) in a vise (AA) with the gerotor end up.

21. Install parts in housing.

22. Align holes of wear plate with housing holes.

23. Make sure drive shaft slot fits on pin and holes of wear plate align with holes of housing.

24. Align holes of gerotor with holes of wear plate.

25. Install cap screws and tighten in a criss-cross pattern to **17 N•m (150 lb-in.)**.

26. Remove steering valve from vise. Install ball, O-ring and plug. Tighten plug to **17 N•m (150 lb-in.)**.

# HYDRAULICS REPAIR

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# STEERING TABLE OF CONTENTS

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# STEERING TABLE OF CONTENTS

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# STEERING SPECIFICATIONS

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## Specifications

### General Specifications

#### Steering:

Type .....	Sector and Pinion
Toe-In - Front Wheels - Front Distance Should Be .....	5 - 25 mm (0.2 - 1.0 in.) less than the rear distance
Front Wheel Sidewall to Draft Bracket .....	0 - 2 mm (0.0 - 0.08 in.) difference
Toe-In - Rear Wheels - Front Distance Should Be .....	5 mm (0.2 in.) toe OUT - 15 mm (0.6 in.) toe IN
Rear Wheel Sidewall to Hitch Plate Hole .....	0 - 2 mm (0.0 - 0.08 in.) difference

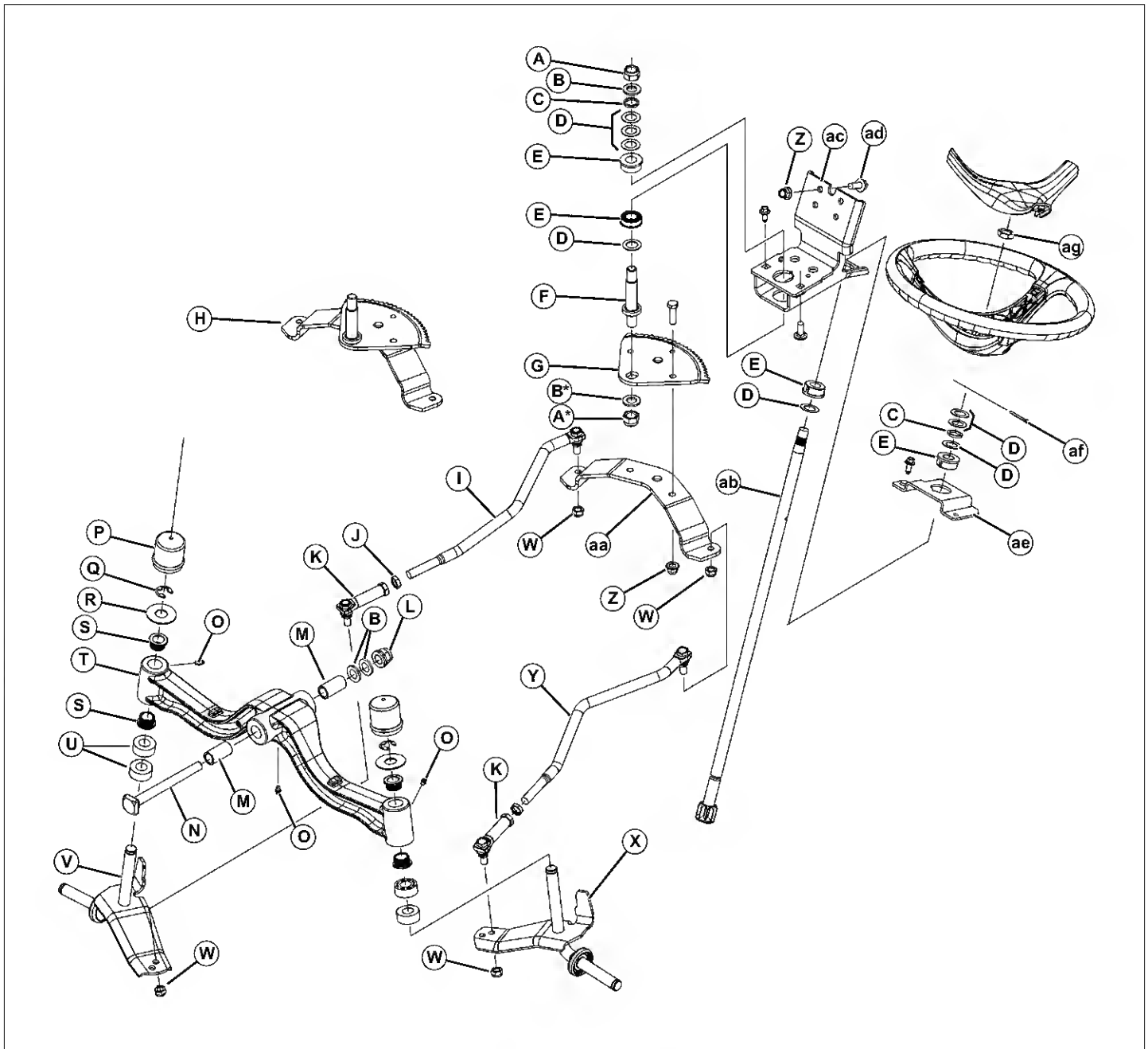
#### Torque Specifications

Front Axle Pivot .....	122 N•m (90 lb-ft)
Muffler Bracket to Front Frame .....	16 N•m (12 lb-ft)
Muffler to Engine Nuts .....	24 N•m (18 lb-ft)
Tie Rod Ball Joint Nut .....	48 N•m (35 lb-ft)
Ball Joint Jam Nut .....	48 N•m (35 lb-ft)
Rear Kingpin .....	475 N•m (350 lb-ft)
Cylinder to Axle Casting .....	52 N•m (38 lb-ft)
Cylinder Rod End to Steering Arm .....	115 N•m (85 lb-ft)
Front Tie Rod Ball Joint Nut .....	48 N•m (35 lb-ft)
4WS Rear Tie Rod and Sector Link .....	108 N•m (80 lb-ft)

# STEERING COMPONENT LOCATION

## Component Location

### Steering Components - 2WS



MX36687

A- Lock Nut M16 (\*bottom washer and nut only used on SN -040000)  
 B- Washer 17x30x3 mm (SN -040000)  
 C- Spring Washer  
 D- Washer  
 E- Bushing  
 F- Shaft (SN -040000)  
 G- Sector Gear (SN -040000)  
 H- Sector Gear Weldment (SN 040001-)

I- Tie Rod, RH  
 J- Nut M14  
 K- Tie Rod End  
 L- Lock Nut M16  
 M- Bushing  
 N- Bolt  
 O- Grease Fitting  
 P- Cap  
 Q- Snap Ring

## STEERING COMPONENT LOCATION

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R- Washer 13/16x2x0.06 in.  
S- Bearing  
T- Front Axle  
U- Spacer\*\*  
V- Spindle, RH  
W- Lock Nut M10  
X- Spindle, LH  
Y- Tie Rod, LH  
Z- Lock Nut M12 (SN -040000)  
AA- Steering Arm Plate (SN -040000)  
AB- Steering Pinion Shaft  
AC- Support Bracket  
AD- Screw M10x25  
AE- Plate  
AF- Cotter Pin 4x32 mm  
AG- Nut M16

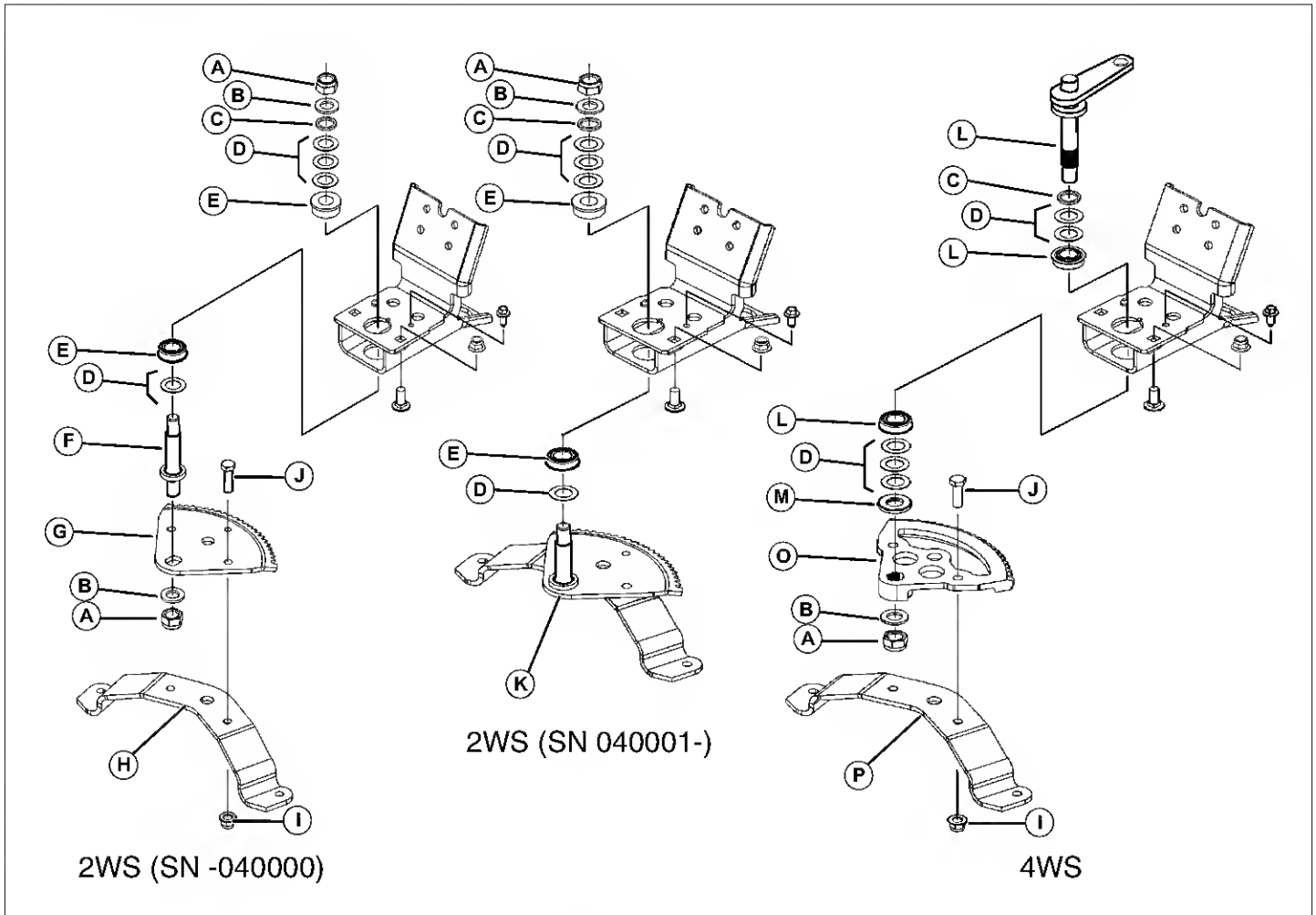
### **Spacer Use:**

(SN -85000) X300 and X320 use two below axle; X340 use one below and one above axle.

(SN 85001-) X320 and X340 use one below axle.

# STEERING COMPONENT LOCATION

## Steering Sector Components

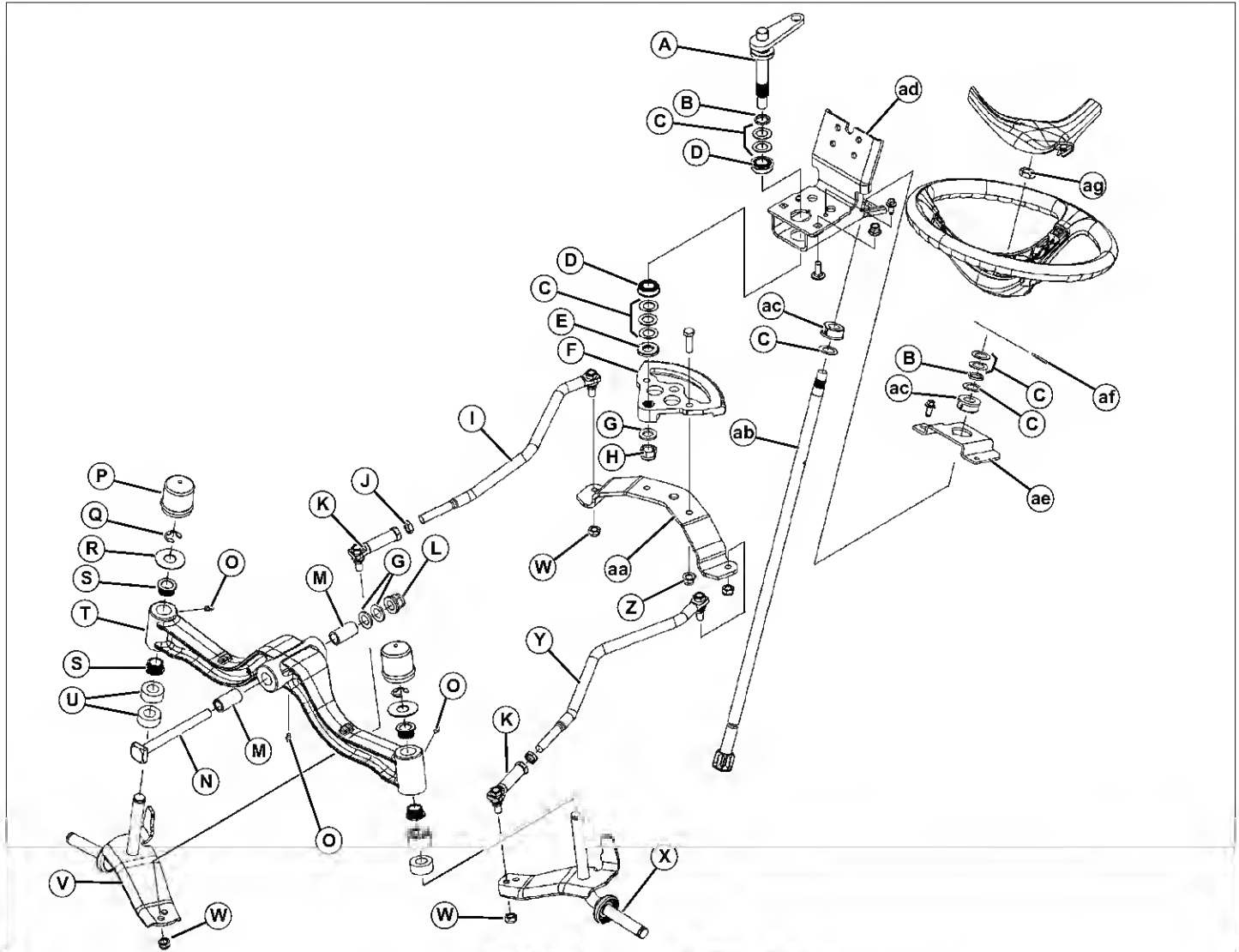


MX36688

- A- Lock Nut M16
- B- Washer 17x30x3 mm
- C- Spring Washer
- D- Washer
- E- Bushing - 2WS
- F- Shaft - 2WS (SN -040000)
- G- Sector Gear - 2WS (SN -040000)
- H- Steering Arm Plate (SN -040000)
- I- Lock Nut M10 (2 used)
- J- Cap Screw M10x35 (2 used)
- K- Steering Sector Weldment (SN 040001-)
- L- Shaft - 4WS
- M- Bushing - 4WS
- N- Washer - 4WS
- O- Sector Gear - 4WS
- P- Steering Arm Plate

# STEERING COMPONENT LOCATION

## Steering Components - 4WS Front

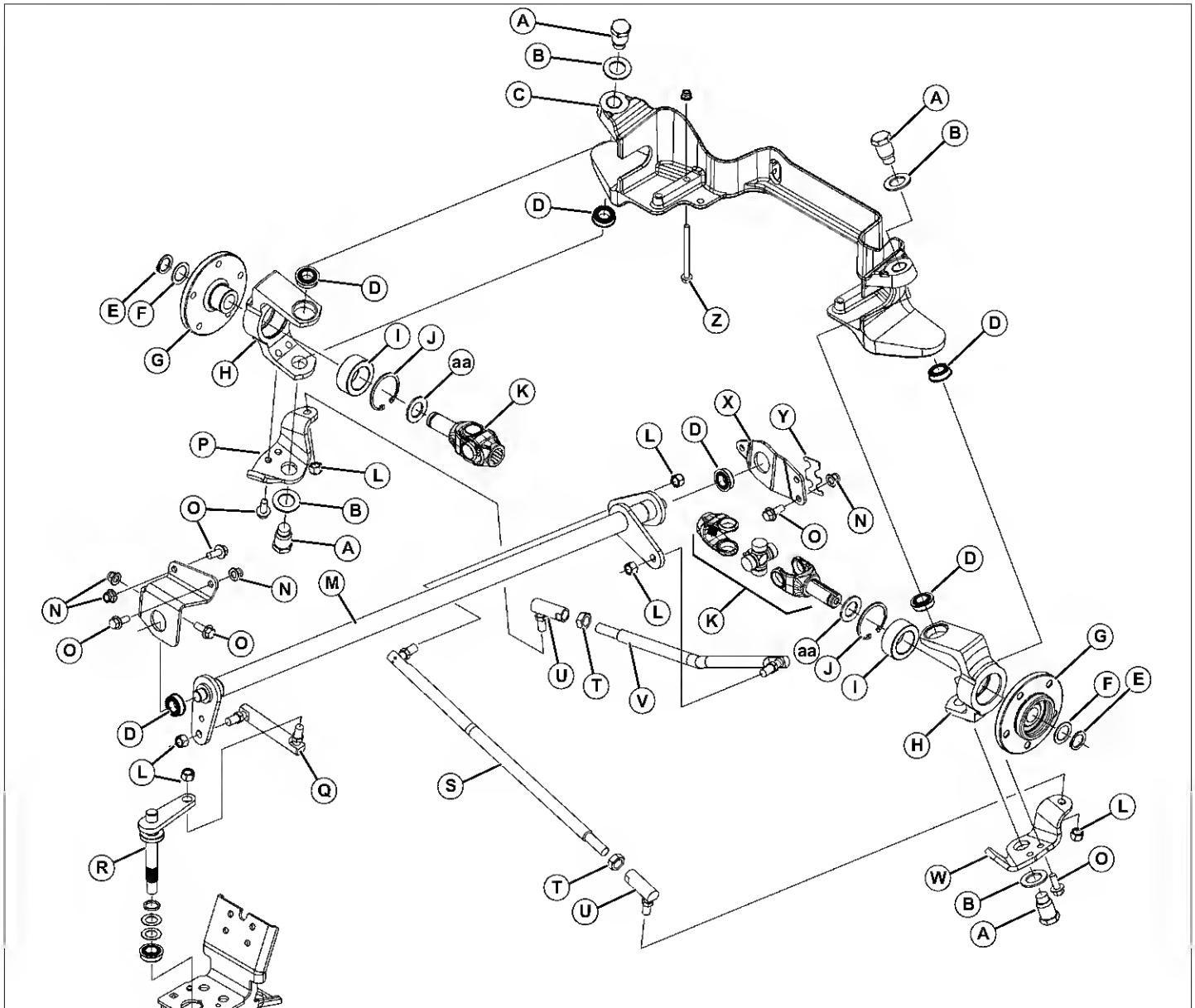


MX36690

- |                      |                              |
|----------------------|------------------------------|
| A- Shaft             | Q- Snap Ring                 |
| B- Spring Washer     | R- Washer 13/16x2x0.06 in.   |
| C- Washer            | S- Bearing                   |
| D- Bearing           | T- Front Axle                |
| E- Splined Washer    | U- Spacer (2 used SN -85000) |
| F- Sector Gear       | V- Spindle, RH               |
| G- Washer 17x30x3 mm | W- Lock Nut M10              |
| H- Lock Nut M16      | X- Spindle, LH               |
| I- Tie Rod, RH       | Y- Tie Rod, LH               |
| J- Nut M14           | Z- Lock Nut M12              |
| K- Tie Rod End       | AA- Plate                    |
| L- Lock Nut M16      | AB- Steering Pinion Shaft    |
| M- Bushing           | AC- Bushing                  |
| N- Bolt              | AD- Support Bracket          |
| O- Grease Fitting    | AE- Plate                    |
| P- Cap               | AF- Cotter Pin 4x32 mm       |
|                      | AG- Nut M16                  |

# STEERING COMPONENT LOCATION

## Steering Components - 4WS Rear



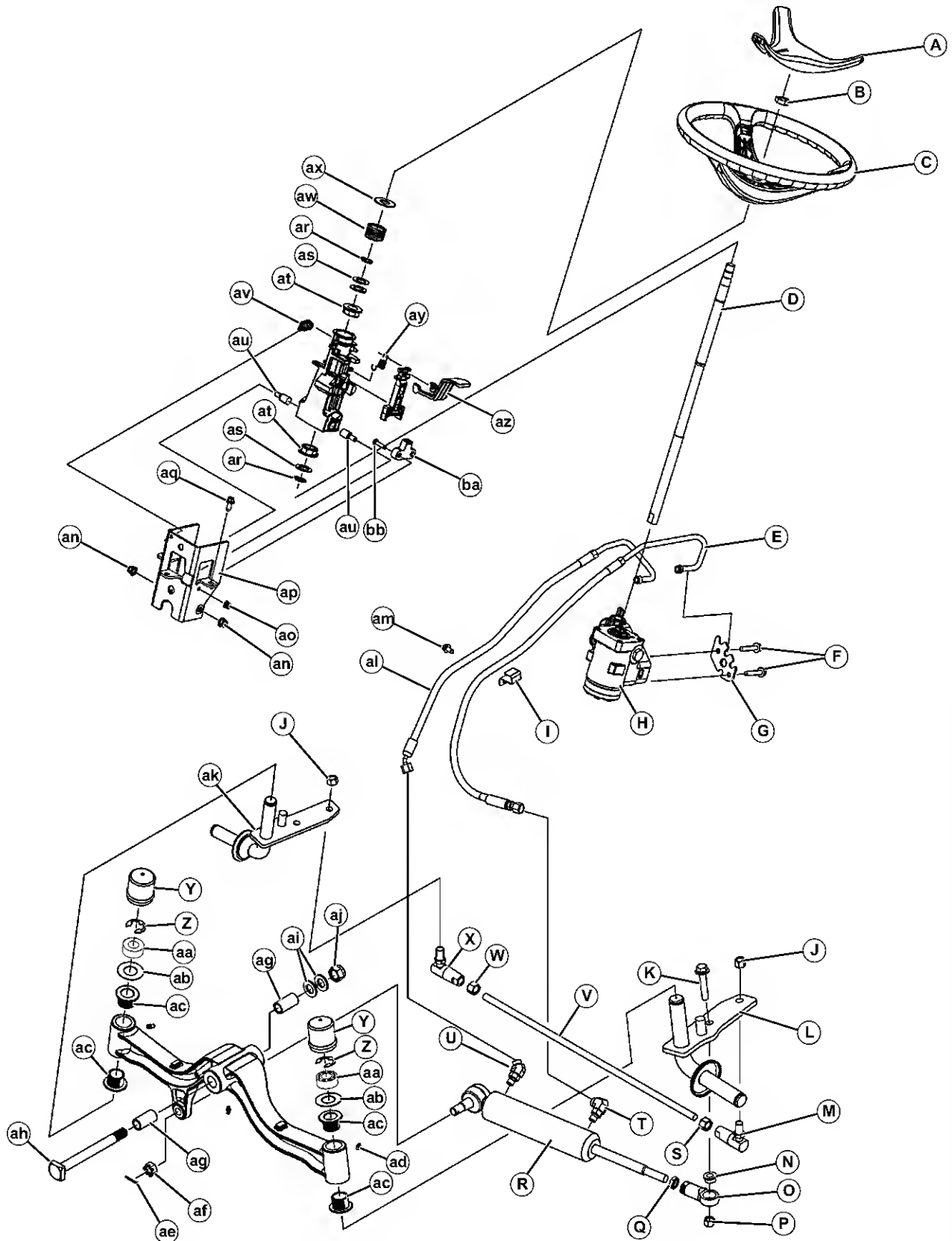
MX36691

- A- Kingpin Bolt
- B- Washer 1-1/32x1-3/4x0.105 in.
- C- Rear Axle Support
- D- Ball Bearing
- E- Snap Ring
- F- Washer 1-1/64x1-1/2x0.048 in.
- G- Wheel Hub
- H- Knuckle
- I- Ball Bearing
- J- Snap Ring
- K- Universal Joint with Shaft
- L- Lock Nut M12
- M- Shaft (Front to Rear)

- N- Lock Nut M10
- O- Screw M10x25
- P- Steering Arm RH
- Q- Rod
- R- Shaft ("A" in Steering Components - 4WS Front)
- S- Tie Rod
- T- Nut 5/8 in.
- U- Ball Joint
- V- Tie Rod
- W- Steering Arm LH
- X- Support
- Y- Spacer (As Required)
- Z- Screw M8x100 with Lock Nut
- AA- Washer 1-1/32x1-3/4x0.105 in. (SN -040000)

# STEERING COMPONENT LOCATION

## Power Steering Components - X360



# STEERING COMPONENT LOCATION

MX40432

A- Cover  
B- Nut M16  
C- Steering Wheel  
D- Steering Shaft, Flexible  
E- Hydraulic Line  
F- Cap Screw (2 used)  
G- Clamp Bracket  
H- Steering Control Unit (SCU)  
I- Clamp  
J- Lock Nut M12 (2 used)  
K- Screw M12x60  
L- Spindle, LH  
M- Ball Joint, LH  
N- Bushing  
O- Rod End  
P- Lock Nut  
Q- Nut M12  
R- Steering Cylinder  
S- Nut M12  
T- Elbow Fitting (with O-rings)  
U- Elbow Fitting (with O-rings)  
V- Tie Rod  
W- Nut M12  
X- Ball Joint, RH  
Y- Cap (2 used)  
Z- Snap Ring (2 used)  
AA- Spacer (2 used)  
AB- Washer 1-1/32x2x0.036 in. (2 used)  
AC- Bushing (4 used)  
AD- Grease Fitting (3 used)  
AE- Cotter Pin  
AF- Castellated Nut 9/16 in.  
AG- Bushing (2 used)  
AH- Bolt, Axle Pivot  
AI- Washer 17x30x3 mm (2 used)  
AJ- Lock Nut M16  
AK- Spindle, RH  
AL- Hydraulic Line  
AM- Screw  
AN- Lock Nut M8 (2 used)  
AO- Lock Nut M6  
AP- Support Bracket  
AQ- Screw (3 used)  
AR- Snap Ring (2 used)  
AS- Washer (3 used)  
AT- Bushing (2 used)  
AU- Stud (2 used)

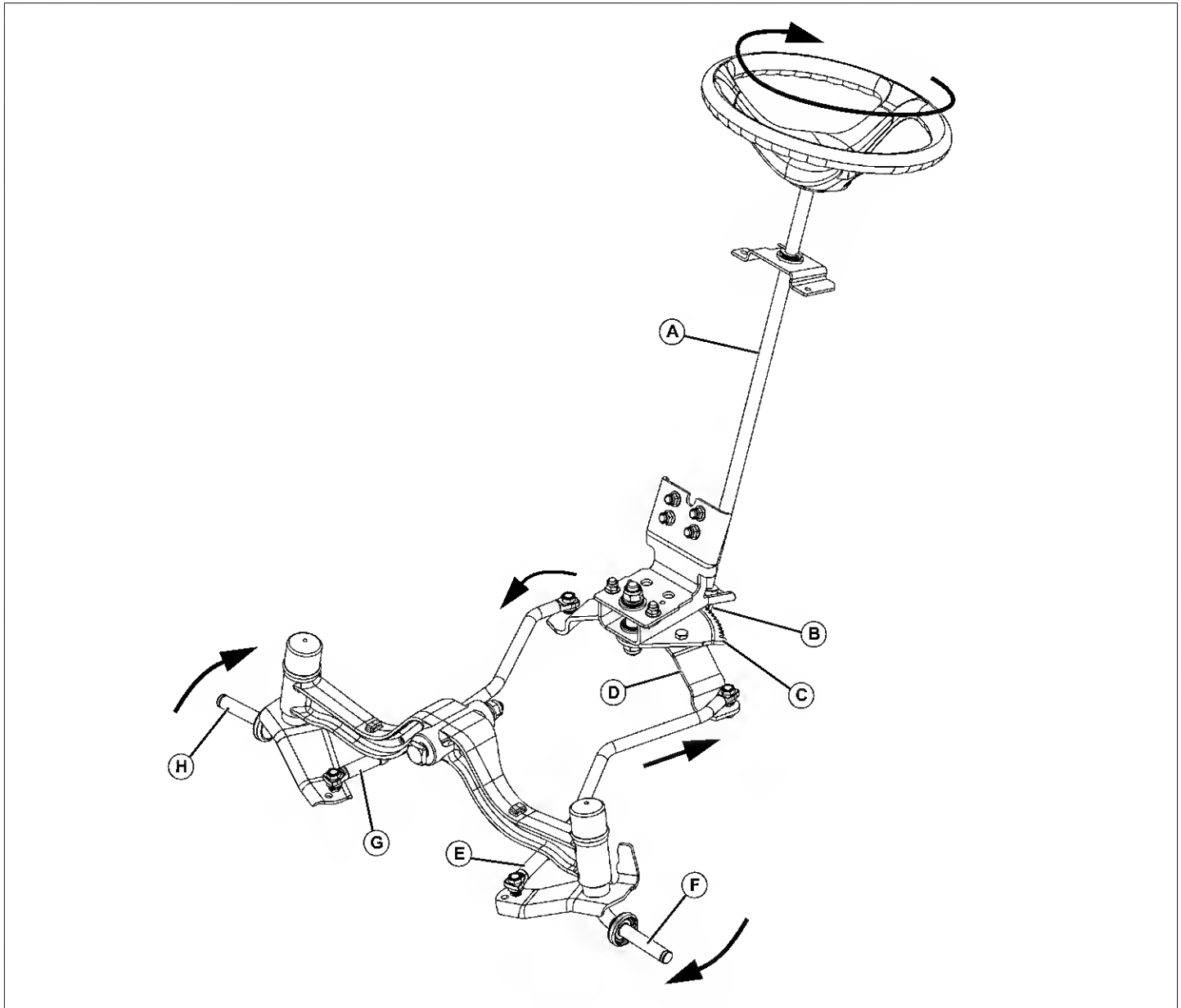
AV- Spring  
AW- Spring  
AX- Thrust Washer  
AY- Spring  
AZ- Handle and Pawl  
BA- Sector, Tilt Steering  
BB- Cap Screw M6x25



# STEERING THEORY OF OPERATION

## Theory of Operation

### Steering System - 2WS



MX36686

the right drag link (G) is moved (forward - right turn, backward - left turn) causing the right spindle (H) to rotate.

#### Function:

To provide directional control of the front wheels in order to turn the machine in the direction desired by the operator.

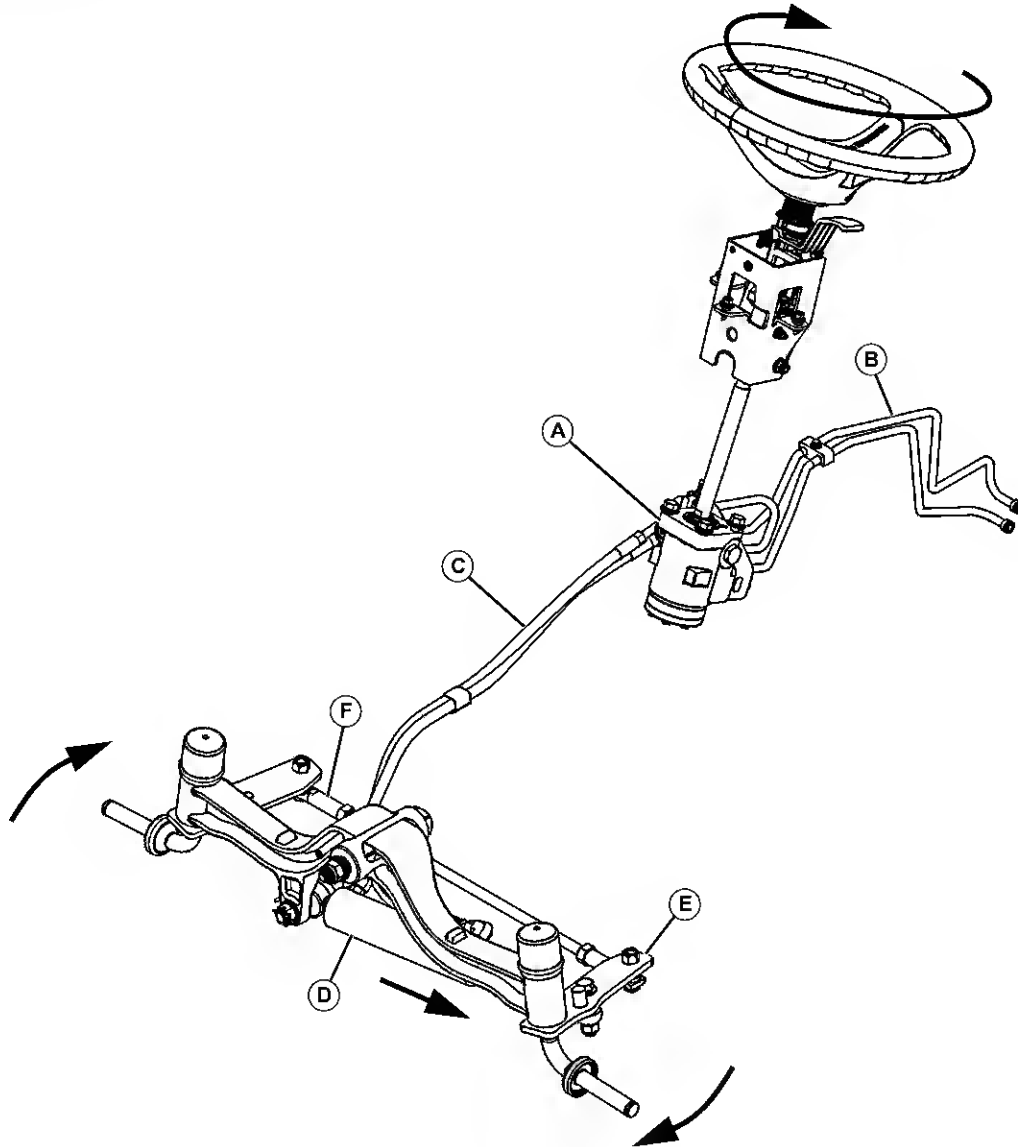
#### Operation:

As the steering wheel is turned, the steering shaft (A) rotates pinion (B) which meshes with the sector gear (C). The sector gear is bolted to the steering arm plate (D).

As the steering arm plate rotates with the steering sector, the left drag link (E) is moved (backward - right turn, forward - left turn) causing the left spindle (F) to rotate; and,

# STEERING THEORY OF OPERATION

## Power Steering System - X360



MX37125

### Function:

To provide directional control of the front wheels in order to turn the machine in the direction desired by the operator.

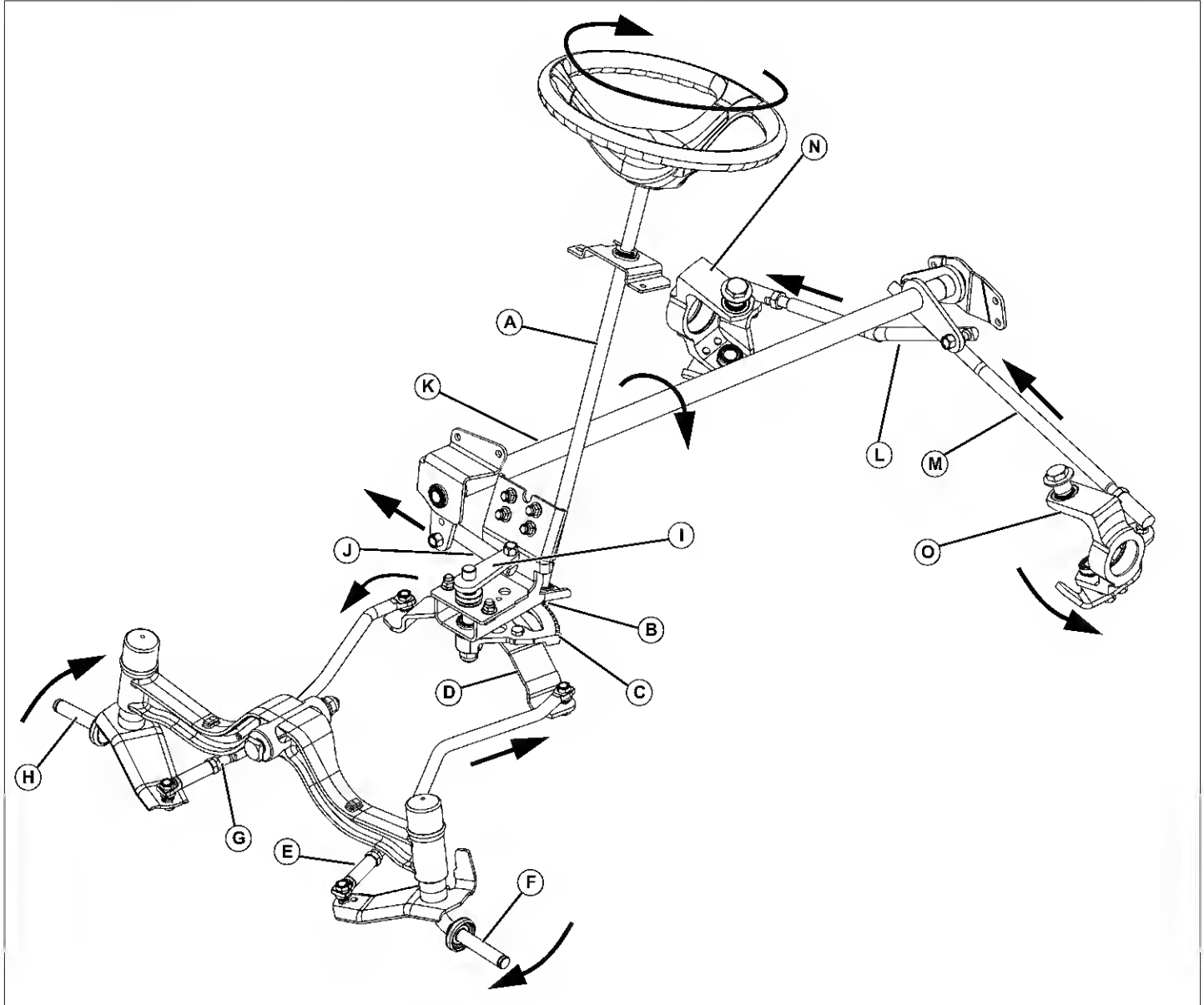
### Operation:

As the steering wheel is turned, the steering shaft rotates and controls a hydraulic spool in the steering control unit (SCU) (A). The spool directs pressure oil from the transaxle pump and hydraulic lines (B) through hydraulic hoses (C) to the steering cylinder (D).

In a right turn the steering cylinder piston would extend causing the left front spindle arm (E) to rotate outward. The tie rod (F) connecting the two spindle arms turns the right spindle to the rear.

# STEERING THEORY OF OPERATION

## Steering System - 4WS



MX36689

rotate.

### Function:

To provide directional control of the front and rear wheels in order to turn the machine in the direction desired by the operator.

### Operation:

As the steering wheel is turned, the steering shaft (A) rotates pinion (B) which meshes with the sector gear (C). The sector gear is bolted to the steering arm plate (D).

As the steering arm plate rotates with the steering sector, the left drag link (E) is moved (backward - right turn, forward - left turn) causing the left front spindle (F) to rotate; and, the right drag link (G) is moved (forward - right turn, backward - left turn) causing the right front spindle (H) to

rotate. As the sector gear (C) rotates it also rotates the crank arm (I) which is connected to the front to rear shaft (K) through rod (J). The front to rear shaft transfers steering input to the rear end of the vehicle and is attached to the right tie rod (L) and left tie rod (M). The other end of the tie rods are connected to their respective right rear spindle (N) and left rear spindle (O).

When the steering wheel is turned the rear wheels turn in the opposite direction of the front wheels - example, in a right hand turn the front wheels turn to the right and the rear wheels turn to the left - and significantly decrease the turning radius of the machine.

# STEERING TESTS AND ADJUSTMENTS

## Tests and Adjustments

### Front Wheel Alignment - Except X360

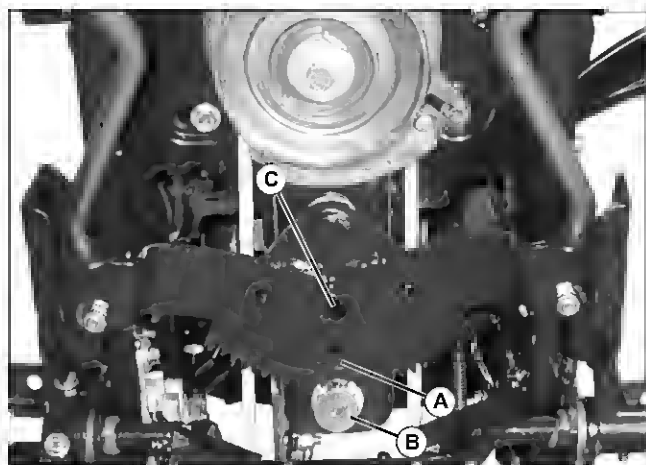
#### Reason:

Correct wheel alignment and toe-in adjustment prevents tire wear and steering wander.

#### Procedure:

1. Park machine safely on a level surface. See "Park Machine Safely" in the Safety section.
2. Check that all four tires are properly inflated. See "General Specifications" on page 559 in the Miscellaneous Section.

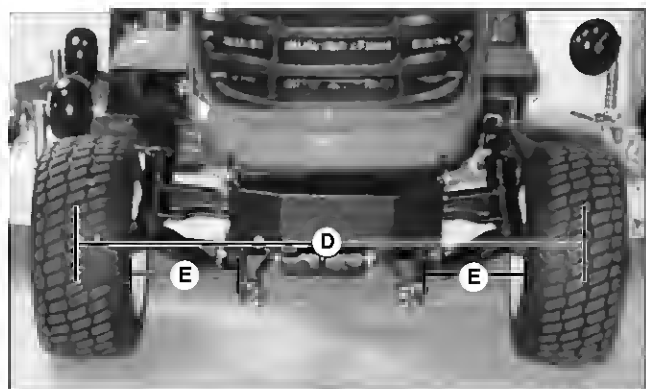
**Note:** Toe-in should not be adjusted with wheels off the ground or on an uneven surface.



MX38479

#### X300 (SN 20001-) shown

3. Place wheels in straight ahead position. Check that the sector gear (A) is centered on the steering shaft gear (B). A 16mm pin or bolt may be inserted in hole (C) in the sector gear and through the matching hole in the sector support bracket to aid in alignment.



MX36534

4. Measure the distance between the center of the tire at

front of tire, hub height (D). Record measurement.

5. Measure the distance between the center of the tire at rear of tire, hub height. Record measurement.

6. Measure the distance at hub height between the inside of each tire (sidewall) to the draft bracket (E) at the front of the tire. Record measurement.

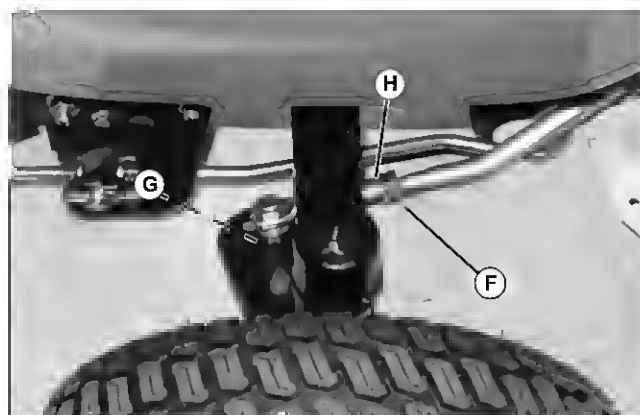
7. Compare all measurements to specifications.

#### Specifications:

**Front Distance (D) Should Be . . 5 - 25 mm (0.2 - 1.0 in.) less than the rear distance**

**Front Wheel Sidewall to Draft Bracket (E) 0 - 2 mm (0.0 - 0.08 in.) difference between sides**

#### Results:



MX36535

- If not within specifications;
  - a. Loosen the tie rod lock nut (F).
  - b. Remove nut (G) from the bottom of the spindle. Disconnect the rod end from spindle.
  - c. Turn rod end (H) until alignment and toe-in is to specification.
  - d. Install rod end to spindle. Tighten nut (G).
  - e. Recheck dimensions after tightening nuts. Readjust if necessary.
  - f. Tighten lock nut (F).

#### Specifications:

**Tie Rod Ball Joint Nut . . . . . 48 N•m (35 lb-ft)**

**Ball Joint Jam Nut . . . . . 48 N•m (35 lb-ft)**

# STEERING TESTS AND ADJUSTMENTS

## Front Wheel Alignment - X360

### Reason:

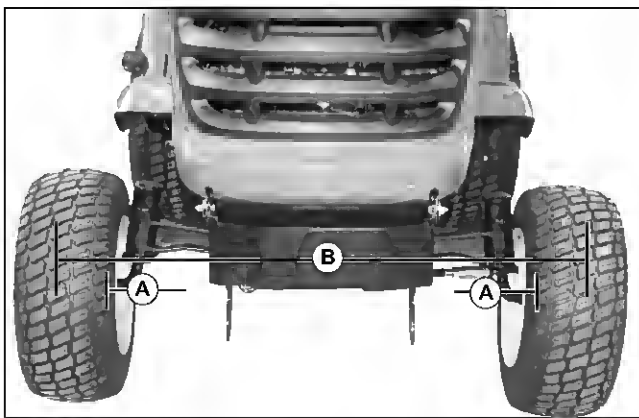
Correct wheel alignment and toe-in adjustment prevents tire wear and steering wander.

### Procedure:

1. Park machine safely on a level surface. See "Park Machine Safely" in the Safety section.

**Note:** *Toe-in should not be adjusted with wheels off the ground or on an uneven surface.*

2. Check that all four tires are properly inflated. See "General Specifications" on page 559 in the Miscellaneous section.

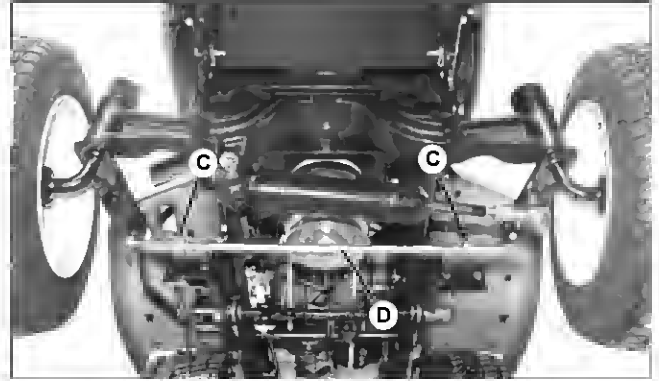


3. Place wheels in straight ahead position. Check that wheels are centered by measuring at (A). Both wheels should be the same distance from the frame.
4. Measure the distance between the center of the tire at front of tire, hub height (B). Record measurement.
5. Measure the distance between the center of the tire at rear of tire, hub height. Record measurement.
6. Measure the distance between the inside of the tire (sidewall) at front of tire to the draft bracket, hub height (A) of each wheel. Record measurement.
7. Measure the distance between the inside of the tire (sidewall) at front of tire to the draft bracket, hub height at back of each wheel. Record measurement.
8. Compare all measurements to specifications.

### Specifications:

**Front Distance (B) should be . . 5 - 25 mm (0.2 - 1.0 in.)  
Less than the rear distance**

### Results:



### Shown from bottom

- If not according to specifications;

**Note:** *Tie rod ends are threaded in opposite directions with left and right hand threads. Check for small notches in the left hand thread jam nut on tie rod end.*

- a. If not according to specifications, loosen the tie rod lock nuts (C).
- b. Turn tie rod (D) until alignment and toe-in is to specification.
- c. Hold tie rod (D) and ball joint in position and tighten both lock nuts (C).
- d. Check dimensions again after tightening nuts and readjust if necessary.

### Specifications:

**Tie Rod Ball Joint Nut . . . . . 88 N•m (65 lb-ft)  
Ball Joint Jam Nut . . . . . 50 N•m (37 lb-ft)**

## Rear Wheel Alignment - X304 and X324

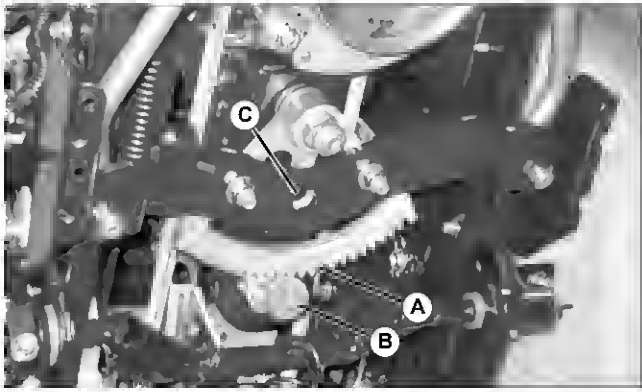
### Reason:

Correct wheel alignment and toe-in adjustment prevents tire wear and steering wander.

### Procedure - Rear Wheels:

1. Park machine safely on a level surface. See "Park Machine Safely" in the Safety section.
2. Check that all four tires are properly inflated. See "General Specifications" on page 559 in the Miscellaneous Section.
3. Check and adjust the front wheel alignment as needed. See "Front Wheel Alignment - Except X360" on page 452.

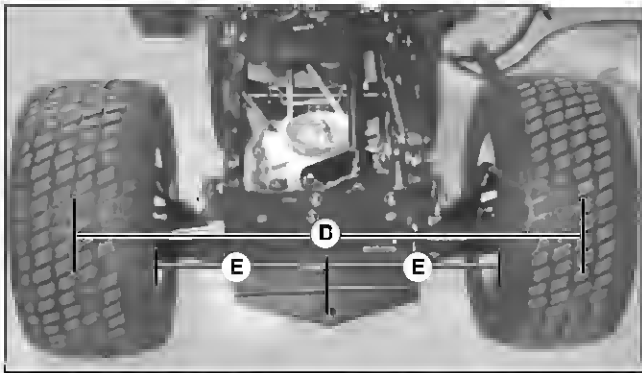
# STEERING TESTS AND ADJUSTMENTS



MX36539

**Picture Note:** X324 shown

4. Place wheels in straight ahead position. Check that the sector gear (A) is centered on the steering shaft gear (B). A 16mm pin or bolt may be inserted in the hole (C) in the sector gear and through the matching hole in the sector support bracket to aid in alignment.



MX36644

**Picture Note:** Fender deck and fuel tank removed for clarity.

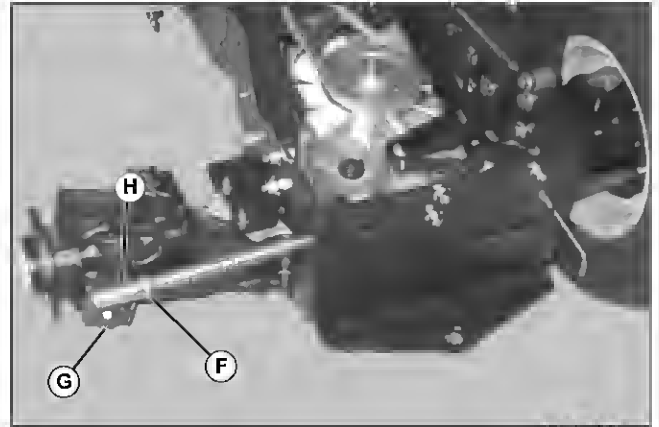
5. Measure the distance between the center of the tire at front of tire, hub height. Record measurement.
6. Measure the distance between the center of the tire at rear of tire, hub height (D). Record measurement.
7. Measure the distance between the inside of the tire (sidewall) at rear of tire to the hitch plate hole, hub height (E) of each wheel. Record measurement.
8. Compare all measurements to specifications.

## Specifications:

**Front Distance (D) Should Be 5 mm (0.2 in.) more than the rear distance to 15 mm (0.6 in.) less than the rear distance**

**Rear Sidewall To Hitch Plate Hole . . . . . 0 - 2 mm (0.0 - 0.08 in.) difference between sides**

## Results:



MX36645

- If not according to specifications;
  - a. Safely lift and support rear of machine and remove rear wheels.
  - b. Loosen the tie rod lock nut (F).
  - c. Remove nut (G) and disconnect the rod end from spindle.
  - d. Turn rod end (H) until alignment and toe-in is to specification.
  - e. Install rod end on spindle and tighten nut (G).
  - f. Check dimensions again after tightening nuts and readjust if necessary.
  - g. Tighten lock nut (F).
  - h. Install rear wheels.

## Specifications:

**Rear Wheel Lug Bolts . . . . . 88 N•m (65 lb-ft)**

**Tie Rod Ball Joint Nut . . . . . 108 N•m (80 lb-ft)**

**Ball Joint Jam Nut . . . . . 48 N•m (35 lb-ft)**

# STEERING TESTS AND ADJUSTMENTS

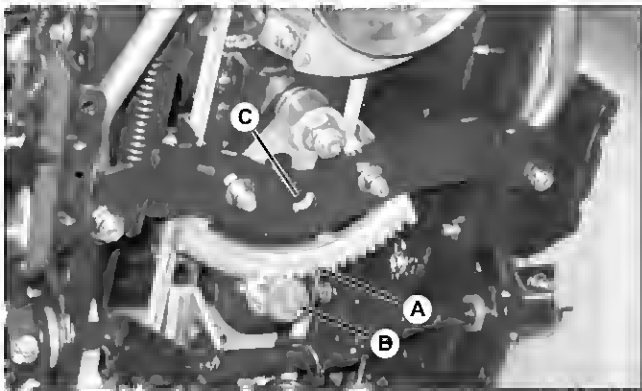
## Tracking Adjustment 4WS - X304 & X324

### Reason:

Correct wheel alignment of front and rear wheels prevents tire wear and steering wander.

### Procedure

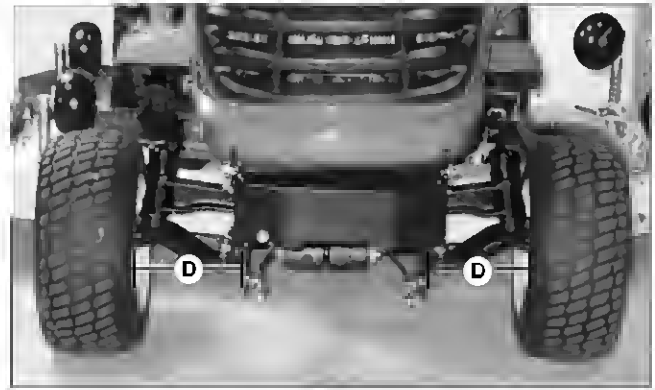
1. Drive machine in a straight line on a flat level surface. Note if rear wheels track parallel to the front wheels. Have a second person watch as you drive away from or to them to determine if machine is tracking straight.
  2. If machine is not tracking straight, park machine safely on a level surface. See "Park Machine Safely" in the Safety section.
  3. Check that all four tires are properly inflated. See "General Specifications" on page 559 in the Miscellaneous section.
- Note:** *Toe-in should not be adjusted with wheels off the ground or on an uneven surface.*
4. Check and adjust the front wheel alignment as needed. See "Front Wheel Alignment - Except X360" on page 452.
  5. Check and adjust the rear wheel alignment as needed. See "Rear Wheel Alignment - X304 and X324" on page 453.



MX36539

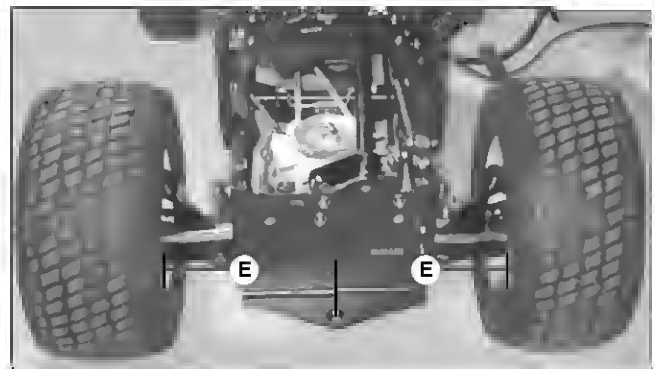
**Picture Note:** X324 shown

6. Place wheels in straight ahead position. Check that the sector gear (A) is centered on the steering shaft gear (B). A 16mm pin or bolt may be inserted in the hole (C) in the sector gear and through the matching hole in the sector support bracket to aid in alignment.



MX36534

7. Measure the distance (D) between the front draft bracket and the inside of the wheel at hub level. They should be identical.



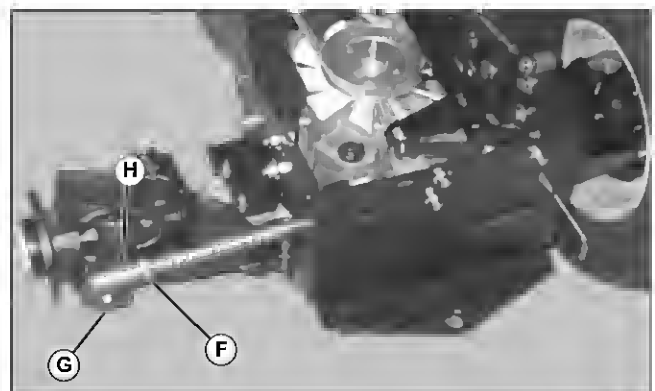
MX36634

**Picture Note:** Fender deck and fuel tank removed for clarity.

8. Measure the distance (E) from the inside of the wheel hubs to the center of the hitch pin. They should be identical.

### Results:

**Note:** *There is free-play in the joints that connect the front and rear steering systems. During final adjustment, move the rear tires back and forth to center any free play and ensure accurate centering of the rear system.*



MX36645

# STEERING REPAIR

- If not according to specifications;
  - a. Safely lift and support rear of machine. Remove both rear wheels.
  - b. Loosen the tie rod lock nut (F).
  - c. Remove nut (G) and disconnect the rod end from spindle.
  - d. Turn rod end (H) until alignment and toe-in is to specification.
  - e. Install rod end on spindle and tighten nut (G).
  - f. Check dimensions again after tightening nuts and readjust if necessary.
  - g. Tighten lock nut (F).
  - h. Install rear wheels.
  - i. Drive machine and readjust as necessary.

**Note:** Once the unit is adjusted for toe-in and front-to-rear tracking, turn the unit fully left and fully right. Check for adequate clearance between the moving parts.

- Specific areas of interest are between the rear tie rods and the top of the hitch plate and the rear torque shaft support bracket. If there is marginal clearance or interference in this area, the rear wheels have been offset in one direction or the other. If the RH rear tire contacts the frame then the right side link has been set too short. Increase the length of the right link by approximately 5 mm (0.2 in) and shorten the left rear steering link by the same amount and start the process over. Front toe-in will be unaffected. If the LH rear tire contacts the frame then the left side link has been set too short. Increase the length of the left link by approximately 5 mm (0.2 in) and shorten the right rear steering link by the same amount and start the process over. Again, front toe-in will be unaffected.

## Specifications:

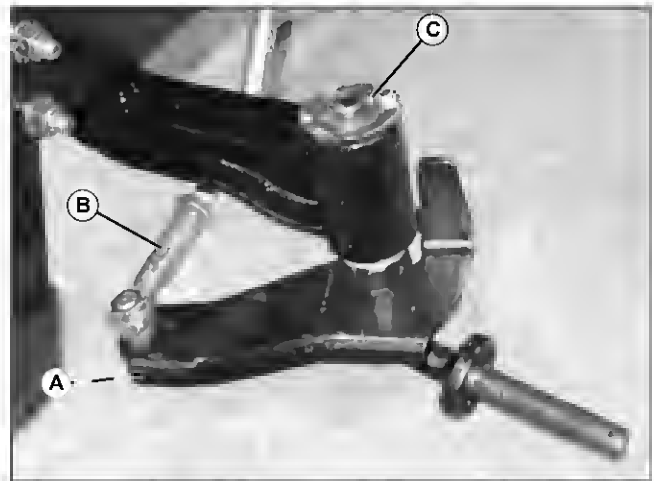
Rear Wheel Lug Bolts .....	88 N•m (65 lb-ft)
Tie Rod Ball Joint Nut .....	60 N•m (44 lb-ft)
Ball Joint Jam Nut .....	50 N•m (37 lb-ft)

## Repair

### Front Steering Spindles

#### Removal:

1. Park machine safely with park brake locked. See "Parking Safely" in the Safety section.
2. Safely lift and support front of machine.
3. Remove front wheels.

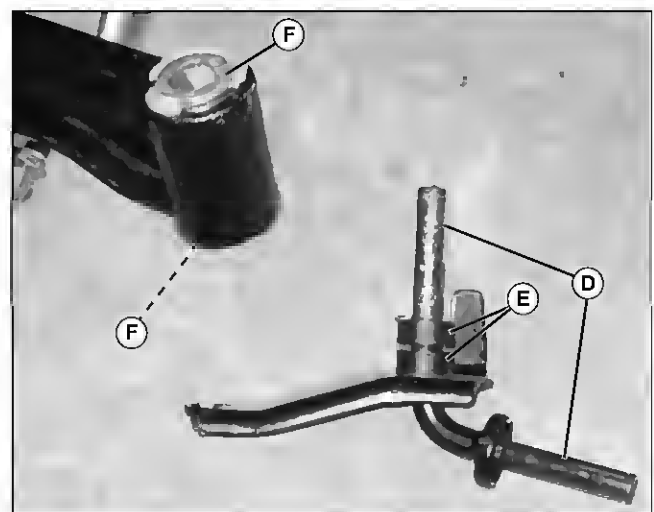


MX36536

4. Remove nut (A) under the spindle. Separate tie rod end (B) from spindle.
5. Remove retaining ring (C) and washer.

**Note:** Note position of spindle spacers (E) before removal.

6. Remove spindle and spacers.



MX36537

7. Inspect spindle shafts (D) and spacers (E) (varies by model) for wear or damage. Replace if necessary.



# STEERING REPAIR

8. Inspect bushings (F) for wear or damage. See "Bushings Replacement" procedure below.

## Bushing Replacement:

- Inspect bushings for wear or damage.
- Bushings (F) are press-fit. Replace using a bushing driver set.
- Apply multipurpose grease to lubrication fittings.

## Spacer Use:

(SN -85000) X300 and X320 use two below axle; X340 use one below and one above axle; X304 and X324 use two below axle.

(SN 85001-) X300, X304 and X324 do not use spacers; X320 and X340 use one below axle.

## Installation:

Installation is done in the reverse order of removal.

- Tighten ball joint nuts to specifications.
- Apply multipurpose grease to lubrication fittings.
- Adjust toe-in. See "Toe-In Adjustment" in the appropriate Steering section.

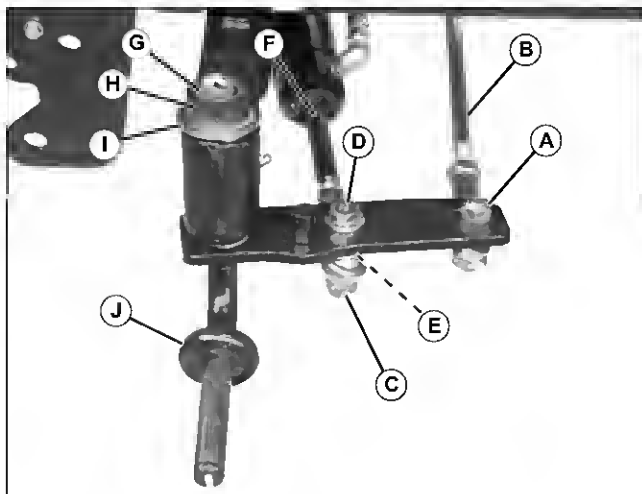
## Specifications:

**Tie Rod Ball Joint Nut** . . . . . 48 N•m (35 lb-ft)

## Front Steering Spindles - X360

### Removal:

1. Park machine safely with park brake locked. See "Park Machine Safely" in the Safety section.
2. Safely lift and support front of machine.
3. Remove front wheels.
4. Remove dust cap from top of spindle.

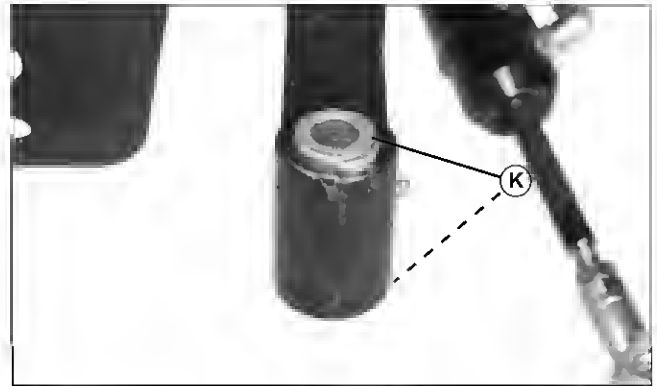


MX40436

5. Remove nut (A) and tie rod (B) from steering arm.

6. Remove lock nut (C), bolt (D), spacer (E) and steering cylinder (F) rod end from steering arm.

7. Remove retaining ring (G), spacer (H), washer (I), and spindle (J).



MX40437

8. Inspect spindle shafts, spacers and bushings (K) for wear or damage. See "Bushings Replacement" procedure below.

## Bushing Replacement:

- Inspect bushings for wear or damage.
- Bushings (K) are press-fit. Replace using a bushing driver set.
- Apply multipurpose grease to lubrication fittings.

## Installation:

Installation is done in the reverse order of removal.

- Tighten tie rod nuts to specifications.
- Apply multipurpose grease to lubrication fittings.
- Adjust toe-in. See "Front Wheel Alignment - X360" on page 453.

## Specifications

**Front Tie Rod Nuts to Steering Arms** . . 88 N•m (65 lb-ft)

**Cylinder Rod End to Steering Arm** . . . 115 N•m (85 lb-ft)

## Steering Gear Assembly Removal and Installation

### Procedure:

1. Park machine safely with park brake locked. See "Parking Safely" in the Safety section.
2. Remove mower deck. See Mower Deck Removal and Installation for the appropriate deck in the Attachments section.
3. Remove hood and disconnect negative (-) battery cable.

## STEERING REPAIR

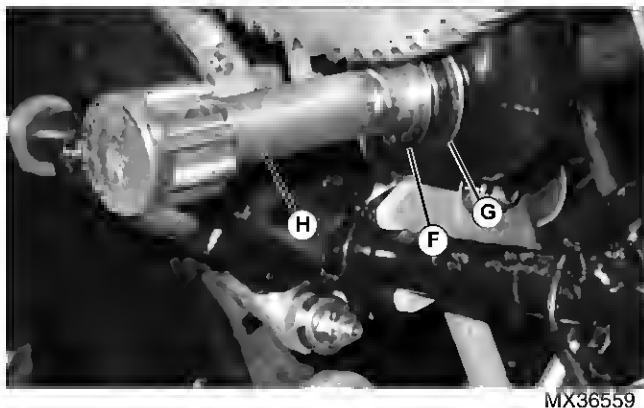
4. Remove steering wheel. See "Steering Wheel Removal and Installation" on page 563.

5. Remove the control panel and steering pedestal. See "Control Panel Removal and Installation" on page 563.



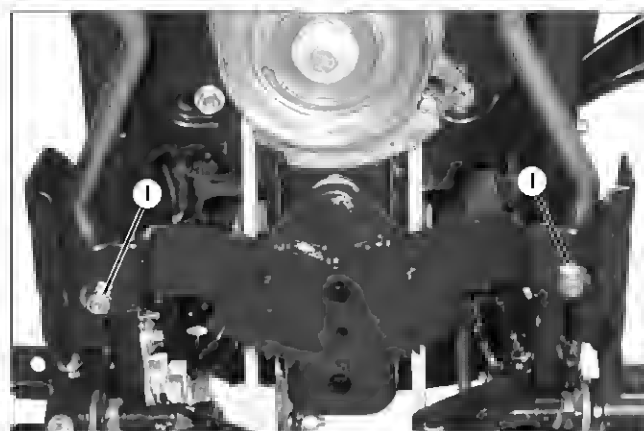
6. Remove cotter pin (A), spacer(s) (B), wave washer (C), spacer (D), and bushings (E) from top of steering wheel shaft.

7. Using a safe lifting device, raise front of machine high enough to allow the steering shaft to be removed.



8. Hold the spacer (F) and bushing (G) in position while removing the steering shaft (H). Then remove the spacer and bushing.

9. For 2WS Machines:



**Picture Note:** X300 (SN 20001-) shown.

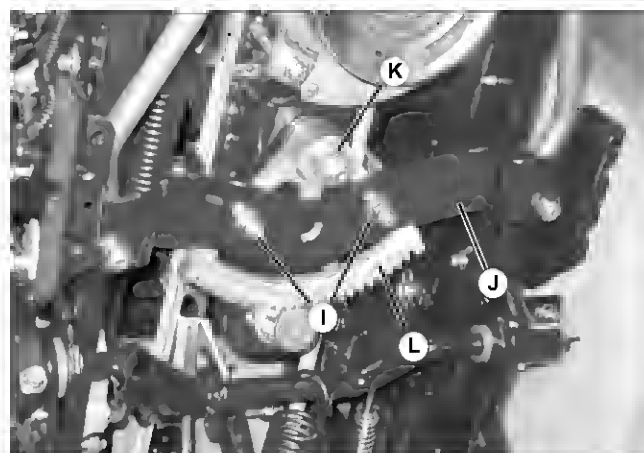
- Disconnect tie rod ends (I) from steering arm plate.



**Picture Note:** X300, X320, and X340

- Remove the upper sector shaft nut (M) and spacer washers.
- Remove the sector shaft and sector gear from the bottom of machine.
- Remove the upper and lower sector shaft bushings.

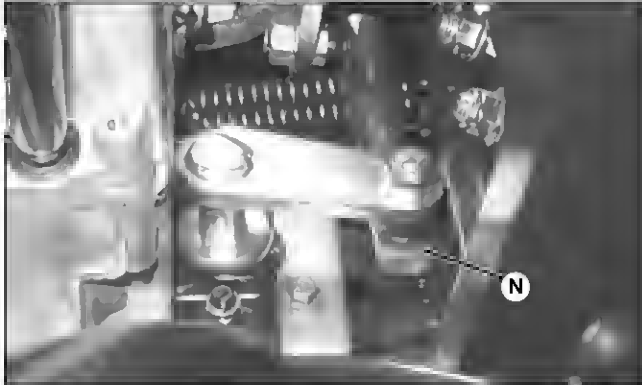
10. For 4WS Machines:



# STEERING REPAIR

**Picture Note: X324 shown.**

- Remove nuts (I) and steering arm (J).
- Remove nut (K). Remove sector gear (L) from bottom of machine.
- Inspect shaft and sector gear, replace as necessary.



MX36560

**Picture Note: X304 and X324**

- Remove the rear steering drag link ball joint (N) from the pinion shaft swing arm.
- Remove the sector shaft and spacer washers through the top of machine.
- Remove the upper and lower sector shaft bushings.
- Inspect shaft and bushings, replace as necessary.

## Installation:

**Note:** If nylon insert lock nut is damaged or can be tightened by hand, replace.

Installation is the reverse of removal.

## Torque Specifications:

Sector Shaft Nuts .....	61 N•m (45 lb-ft)
Steering Arm Mounting Nuts .....	65 N•m (48 lb-ft)
Ball Joint Nut .....	50 N•m (37 lb-ft)
Front Tie Rods .....	48 N•m (35 lb-ft)
Rear Steering Drag Link .....	108 N•m (80 lb-ft)

## Steering Tilt Unit Removal and Installation

### Removal:

1. Park machine safely with park brake locked. See "Park Machine Safety" in the Safety section.
2. Remove mower deck. See Mower Deck Removal and Installation for the appropriate deck in the Attachments section.
3. Remove hood and disconnect negative (-) battery cable.
4. Remove steering wheel. See "Steering Wheel Removal

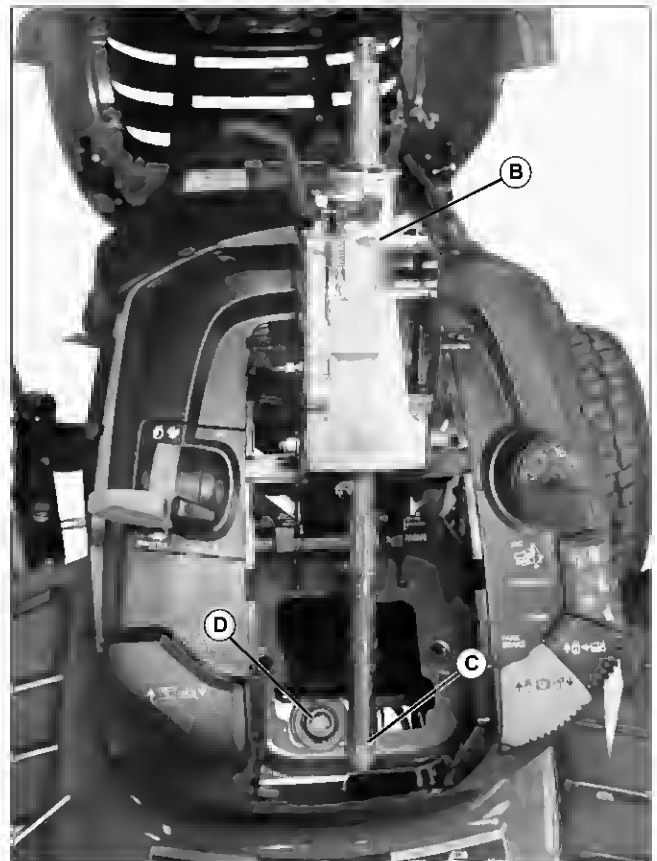
and Installation" on page 563 in the Miscellaneous section.

5. Remove the control center panel. See "Control Panel Removal and Installation" on page 563 in the Miscellaneous section.



MX40438

6. Remove bolts (A) securing steering tilt mechanism to frame.



MX40439

7. Remove tilt steering assembly (B) and flexible steering shaft from top of steering column. Bottom of steering shaft (C) is a slip fit in top of hydraulic steering control unit (D).

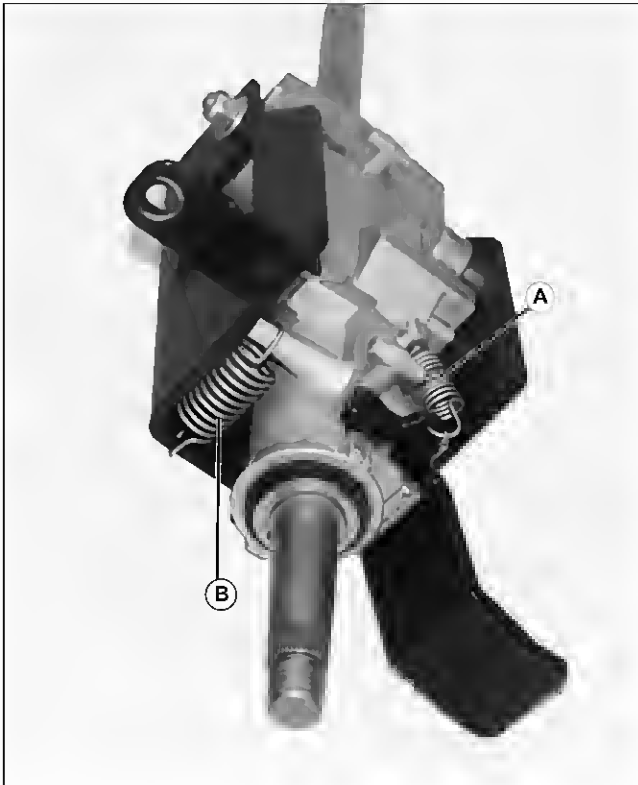
### Installation:

Installation is the reverse of removal.

# STEERING REPAIR

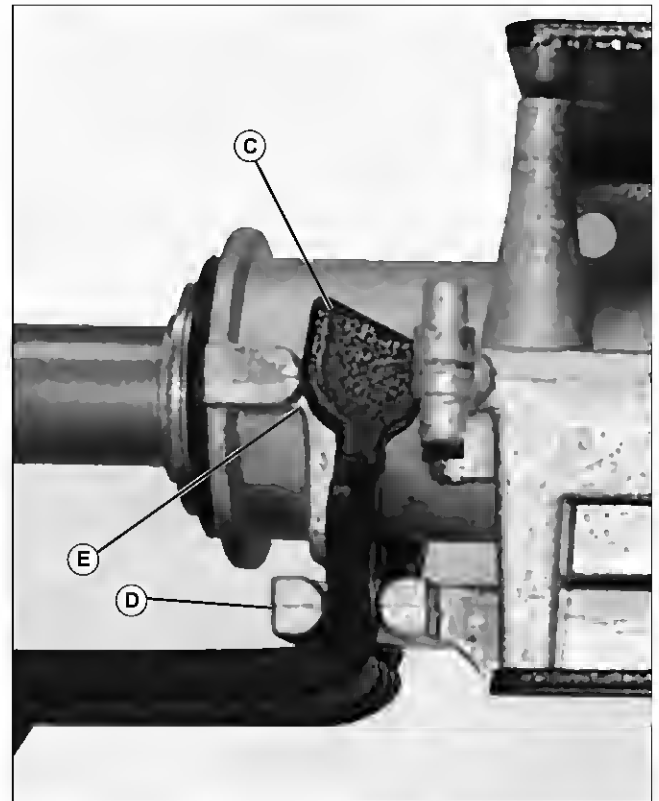
## Steering Tilt Unit Disassembly and Assembly

1. Remove steering tilt unit from frame. See "Steering Tilt Unit Removal and Installation" on page 459.



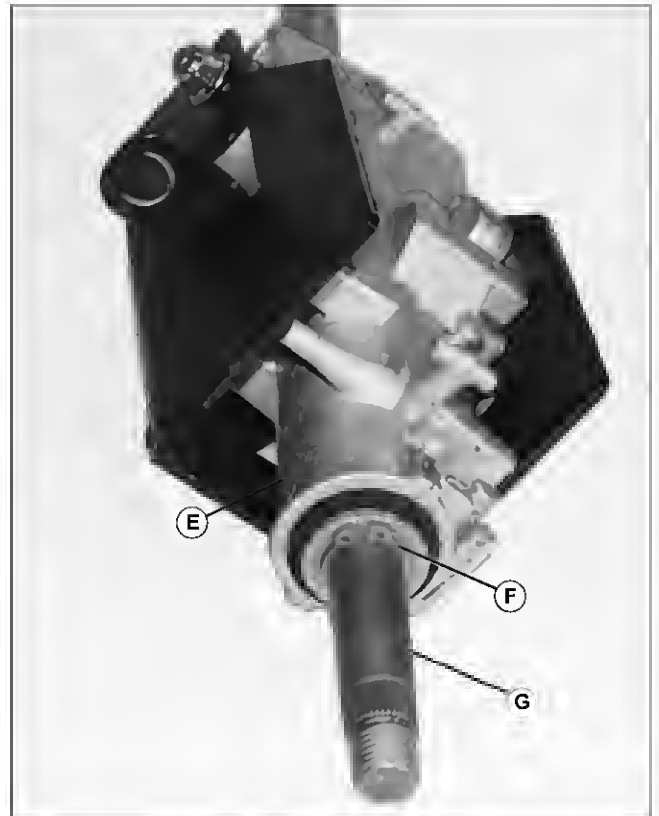
MX37226

2. Remove handle spring (A) and body spring (B). Note orientation of handle spring (A) for installation.



MX37227

3. Remove lock handle (C) from lock (D) and body (E).

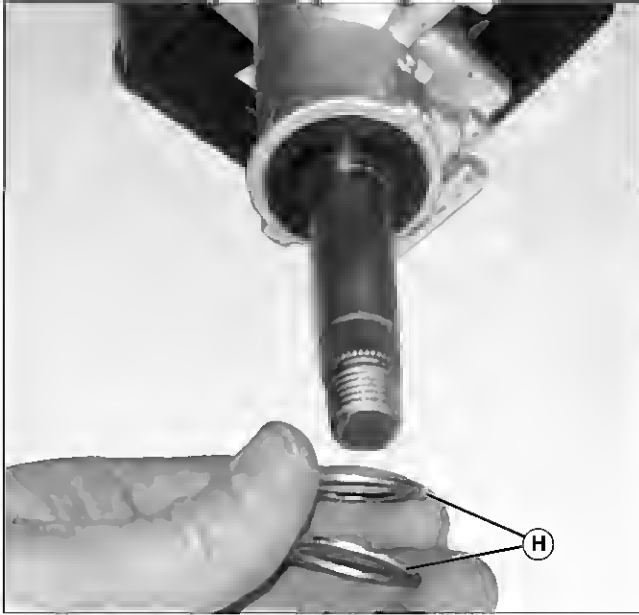


MX37228

4. Remove snap ring (F) that retains steering shaft (G) in

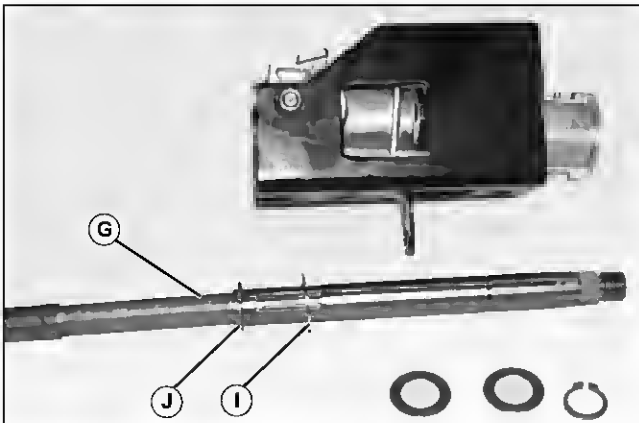
## STEERING REPAIR

body (E).



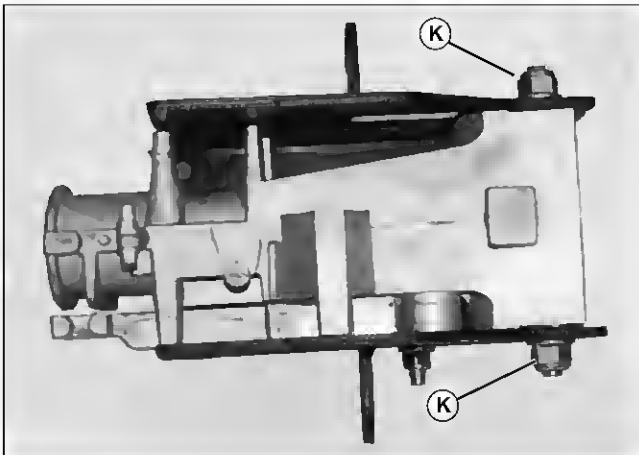
MX37229

5. Remove spacer washers (H) from steering shaft.



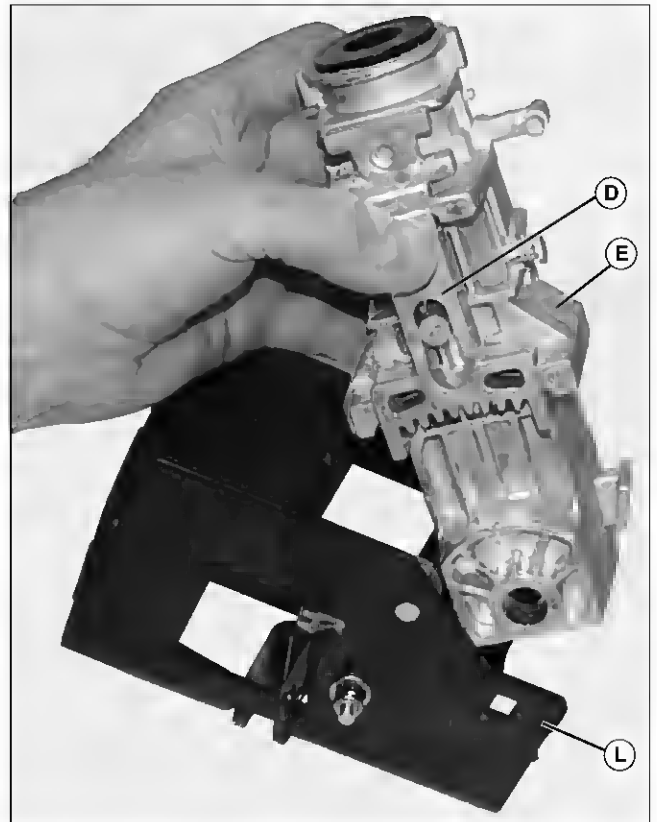
MX37230

6. Remove steering shaft (G) from bottom of body. Note bottom washer (I) and lower snap ring (J).



MX37231

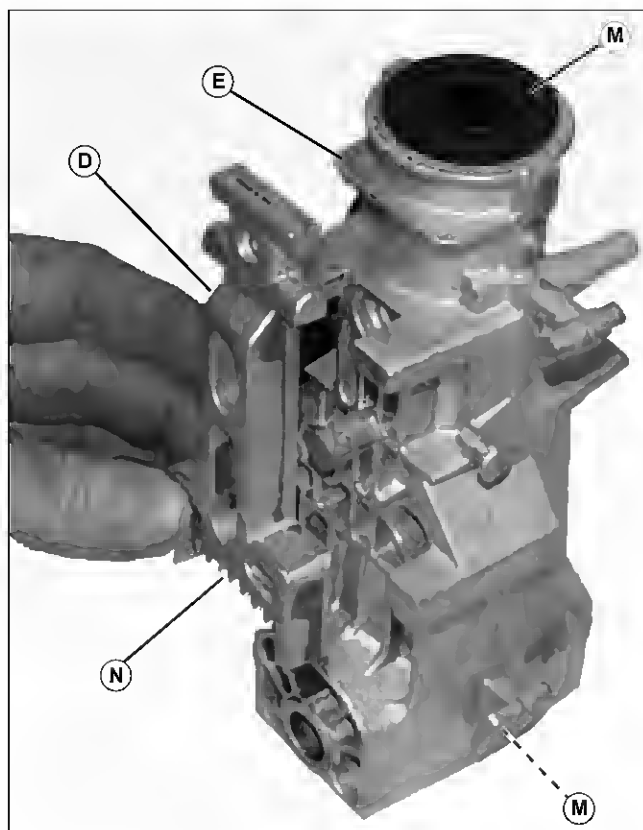
7. Remove the nuts (K) from pivot bolts. Remove pivot bolts from inside of body.



MX37232

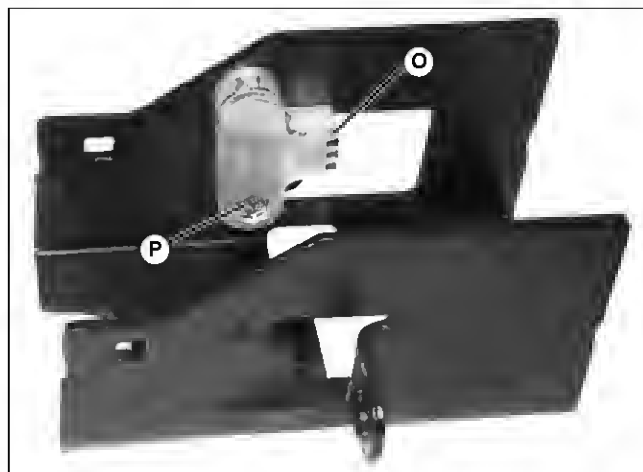
8. Remove body (E) from lock (D) from frame (L).

# STEERING REPAIR



9. Remove lock (D) from body (E). Inspect wear surfaces and teeth (N). Replace if worn or damaged.

10. Inspect bushings (M) on either end of body. Replace if damaged or worn.



11. Inspect lock pawl teeth (O). Replace if damaged or worn by removing bolt (P).

## Assembly:

Assembly is the reverse of disassembly.

Do not use any lubricants or grease on steering system components during assembly.

## Front Axle Removal and Installation

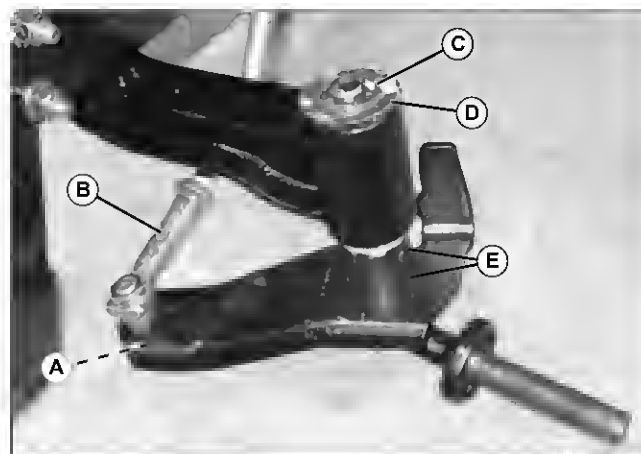
1. Park machine safely with park brake locked. See "Parking Safely" in the Safety section.
2. Remove mower deck. See Mower Deck Removal and Installation for the appropriate deck in the Attachments section.



**Caution: Avoid Injury! To prevent possible burns, allow engine to cool before removing muffler**

3. Remove engine hood.
4. Disconnect negative (-) battery cable.
5. To remove muffler shields and muffler:
  - a. Remove front and side heat shields.
  - b. Remove muffler mounting bracket cap screws securing muffler bracket to frame.
  - c. Remove nuts securing exhaust pipes to engine.
  - d. Remove muffler and gaskets.
6. Safely lift and support front of machine.
7. Remove front wheels.
8. Remove spindles and spacers.

Except X360 (manual steering):



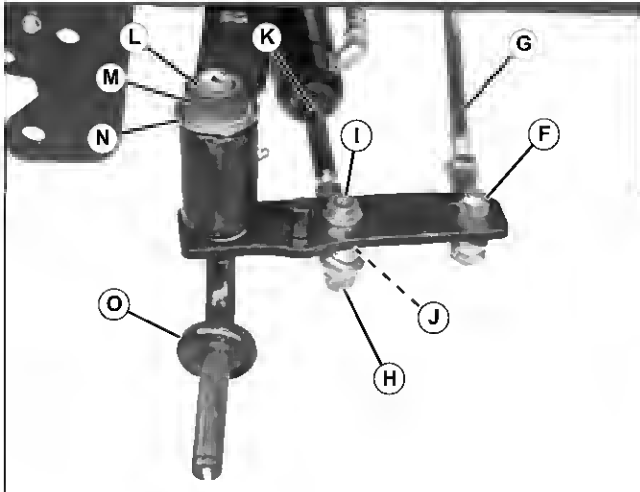
- a. Remove nut (A) and tie rod (B) from steering arm.
- b. Remove retaining ring (C) and washer (D).

**Note: If present, note position of spindle spacer(s) (E) before removal.**

- c. Remove spindle and spacers.

# STEERING REPAIR

X360 (power steering):



MX40436

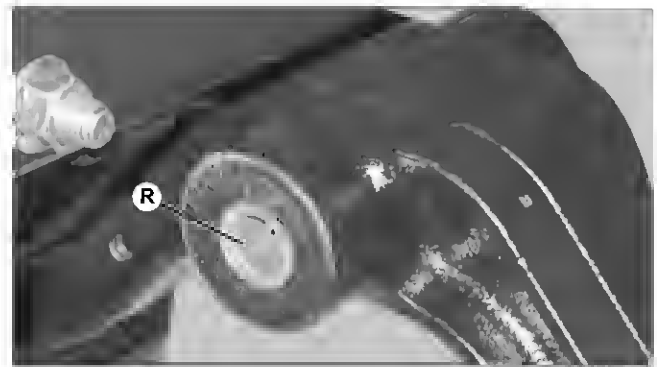
- Remove nut (F) and tie rod (G) from steering arm.
- Remove lock nut (H), bolt (I), spacer (J) and steering cylinder (K) rod end from steering arm.
- Remove retaining ring (L), spacer (M), washer (N), and spindle (O).



MX36538

View from below machine.

- Remove the nut (P) and spacer washers (Q) from the axle pivot bolt.
- Support axle and remove pivot bolt and axle.



MX36643

- Inspect the bushing (R) for wear or damage. Replace as needed.
- Remove axle and replace parts as necessary.

## Installation:

Installation is done in the reverse order of removal.

- Use new gasket for installation.

**Note: If nylon insert lock nut is damaged or can be tightened by hand, replace.**

- Grease and install axle and tighten axle pivot to **122 N•m (90 lb-ft)**.
- Install spindles, spacers, tie rods and power steering cylinder, as equipped.
- Adjusts wheel alignment and toe-in. See "Front Wheel Alignment - Except X360" on page 452 or "Front Wheel Alignment - X360" on page 453.
- Install muffler and tighten muffler-to-engine nuts **24 N•m (18 lb-ft)**.
- Tighten muffler bracket to frame **16 N•m (12 lb-ft)**.
- Install muffler shrouds.
- Install hood.
- Reconnect all electrical connections.

## Steering Spindle Spacer Use (per side):

(SN -85000) X300 uses two below axle; X340 and X320 use one below and one above axle; X304 and X324 use two below axle.

(SN 85001-) X300, X304 and X324 do not use spacers; X320 and X340 use one below axle; X360 uses one above axle.

## Torque Specifications:

Front Axle Pivot .....	122 N•m (90 lb-ft)
Tie Rod Ball Joint Nut .....	48 N•m (35 lb-ft)
Ball Joint Jam Nut .....	48 N•m (35 lb-ft)
Cylinder Rod End to Steering Arm . . .	115 N•m (85 lb-ft)

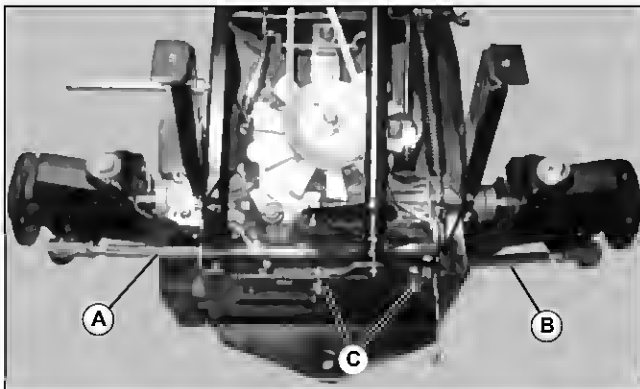
# STEERING REPAIR

Muffler to Engine Nuts . . . . .	24 N•m (18 lb-ft)
Muffler Bracket to Front Frame . . . . .	16 N•m (12 lb-ft)

## Rear Steering Linkage Removal and Installation - X304, X324

### Removal:

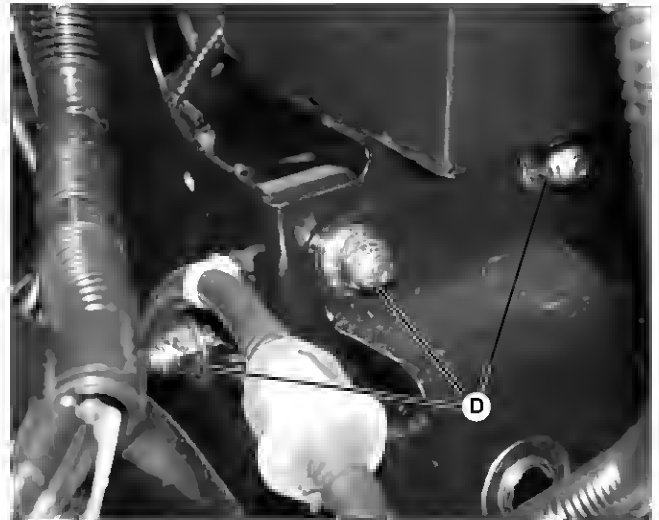
1. Park machine safely with park brake locked. See "Parking Safely" in the Safety section.
2. Remove mower deck. See Mower Deck Removal and Installation for the appropriate deck in the Attachments section.
3. Remove hood.
4. Disconnect negative (-) battery cable.
5. Remove steering wheel. See "Steering Wheel Removal and Installation" on page 563 in Miscellaneous section.
6. Remove the control panel and steering pedestal. See "Control Panel Removal and Installation" on page 563.
7. Remove fender deck. See "Fenderdeck Removal and Installation" on page 566 in Miscellaneous section
8. Remove fuel tank. See "Fuel Tank Removal and Installation" on page 567 in Miscellaneous section.
9. Safely lift and support rear of machine and remove rear wheels.



10. Remove the left (A) and right (B) tie rods.
11. Remove bolts (C) and lock nuts securing rear bearing bracket to frame.



12. Remove the nut securing the rear steering drag link ball joint (C) to the shaft arm. The drag link can not be removed until the next step is accomplished.



13. Remove the three nuts (D) and bolts securing front bracket to frame. Remove bracket.
14. Remove rear steering drag link ball joint from rear steering shaft bracket.
15. Remove front to rear steering shaft from frame.



# STEERING REPAIR



MX37075

16. Inspect shaft and bearings (E) and replace as required.

**Note:** When installing bearings on rear steering shaft be sure to install with flange (E) towards center of shaft as shown.

17. Inspect shaft and bearings and replace as required.

## Installation:

- Installation is the reverse of removal.

**Note:** If nylon insert lock nuts are damaged or can be tightened by hand, replace.

- Front tie rod end must be installed before front bracket is installed.
- Do not tighten front bracket mounting bolts until rear bracket has been installed.

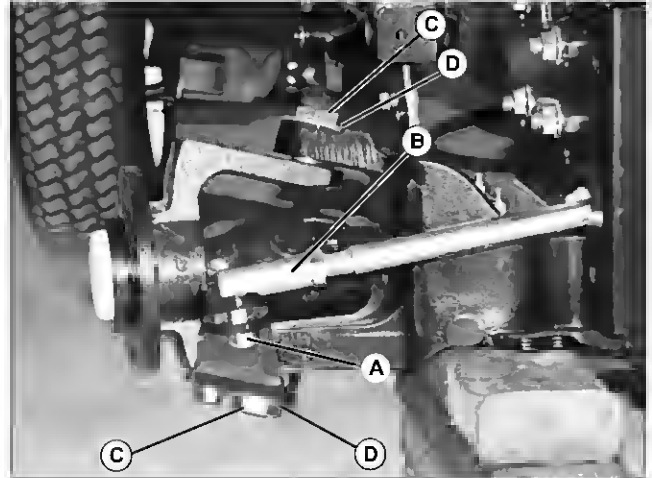
## Torque Specifications:

Ball Joint Nut ..... 108 N•m (80 lb-ft)

## Rear Steering Knuckle Removal and Installation

### Removal:

1. Park machine safely with park brake locked. See "Parking Safely" in the Safety section.
2. Safely lift and support rear of machine.
3. Remove rear wheel on side to be serviced.

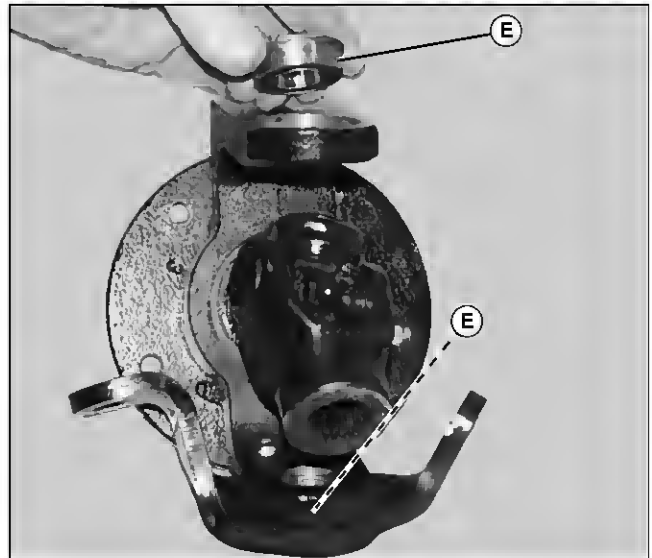


MX37076

4. Remove nut (A) and tie rod (B).
5. Remove upper and lower kingpin bolts (C) and washer (D). Remove knuckle from frame.

### Knuckle Disassembly:

1. Use screwdriver to remove plastic hub cap from outboard end of knuckle.



MX37078

2. Remove upper and lower kingpin bearings (E).

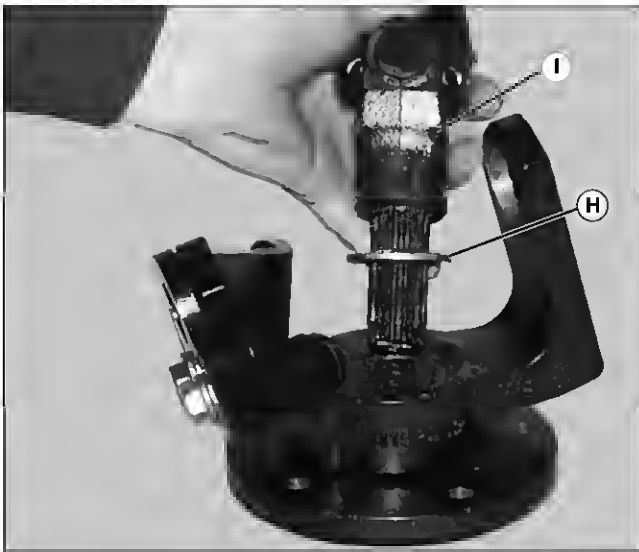
## STEERING REPAIR



MX37077

3. Remove retainer ring (G) and washer (F).

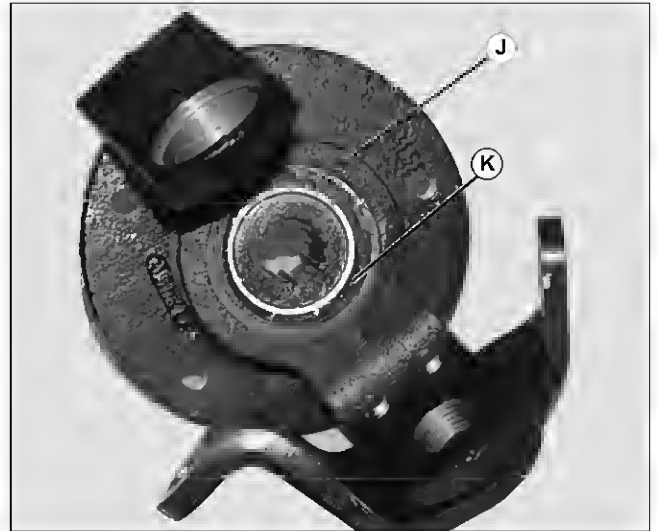
**Note:** Washer (H) used to SN -040000.



MX37079

**Picture Note:** Washer (W) used to SN 20000.

4. Remove U-joint shaft (I) and washer (H), if used, from knuckle.



MX37080

5. Remove retaining clip (J) and bearing (K) from knuckle.  
6. Inspect parts and replace if damaged or worn

### Installation:

Installation is done in the reverse order of removal.

- Tighten tie rod nuts to specifications.
- Tighten kingpin bolts to specifications.
- Apply multipurpose grease to splined end of U-joint shafts and inside of U-joint coupler.
- Adjust wheel alignment. See "Front Wheel Alignment - Except X360" on page 452 and "Rear Wheel Alignment - X304 and X324" on page 453.

### Specifications:

**Tie Rod Ball Joint Nut** ..... 108 N•m (80 lb-ft)

**Kingpin Bolt** ..... 475 N•m (350 lb-ft)

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# ATTACHMENTS SPECIFICATIONS

## Specifications

### Repair Specifications

#### 38, 42C and 42M Mower Decks General Specifications

Type .....	Rotary - Mulch, Bag or Side Discharge
Blade Cutting Edge .....	30 ± 5° Angle
Overall Cutting Width (38 deck) .....	95.5 cm (38 in.)
Overall Cutting Width (42C and 42M deck) .....	106.7 cm (42 in.)
Cutting Height (approximate) .....	25 - 102 mm (1 - 4 in.)
Spindle Lubrication .....	25 hour intervals

#### 38, 42C and 42M Mower Decks To Model Year 2009

Blade Nut (12mm) Torque .....	68 N•m (50 lb-ft)
Gage Wheels-To-Deck .....	34 N•m (25 lb-ft)
Idler Sheave Nuts .....	47 N•m (35 lb-ft)
Spindle Sheave Nut .....	108 N•m (80 lb-ft)
Spindle Mounting Cap Screw .....	30 N•m (22 lb-ft)

#### 38, 42C and 42M Mower Decks Starting Model Year 2010

Blade Nut (5/8 in.) Torque .....	88 N•m (65 lb-ft)
Gage Wheels-To-Deck .....	34 N•m (25 lb-ft)
Idler Sheave Nuts .....	47 N•m (35 lb-ft)
Spindle Sheave Nut .....	108 N•m (80 lb-ft)
Spindle Mounting Nuts .....	30 N•m (22 lb-ft)

#### 38 Inch Deck and Machine Serial Numbers:

Model Year 06 Machines .....	(to MOX3xxA 040000)
Model Year 06 38 Inch Decks .....	(to MO38CPA 020000)
Model Year 07 Machines .....	(start MOX3xxA 040001)
Model Year 07 38 Inch Decks .....	(start MO38CPA 020001)
Model Year 07 48C Single Belt Drive Deck .....	(start MO48SBA 010001)

*Note: Model Year 2007 Decks are listed in this section at serial number break 020001- except the 48C Single Belt Drive deck which starts at SN 10001-. Model Year 2007 machines start at serial number 040001-.*

*If no serial number plate is on the 38-Inch Deck they can be differentiated by the belt tensioning lever (used through Model Year 2006); the deck suspension pin connector ("J" pins used through Model Year 2006, and straight drilled pins used starting in Model Year 2007); or the tensioning spring (compression spring used through Model Year 2006, and extension spring used starting in Model Year 2007).*

#### 48C and 54C Mower Decks

Type .....	Rotary - Mulch, Bag or Side Discharge
Blade Cutting Edge .....	30 ± 5° Angle
Overall Cutting Width (48C deck) .....	121.9 cm (48 in.)
Overall Cutting Width (54C deck) .....	137.1 cm (54 in.)
Cutting Height (approximate) .....	25 - 102 mm (1 - 4 in.)
Blade Nut Torque .....	68 N•m (50 lb-ft)
Gauge Roller Shaft Nut Torque .....	30 N•m (22 lb-ft)
Spindle Sheave Nut Torque .....	142 N•m (105 lb-ft)
Idler Sheave Nuts .....	47 N•m (35 lb-ft)

## ATTACHMENTS SPECIFICATIONS

Spindle Mounting Nut Torque . . . . . 30 N•m (22 lb-ft)  
Spindle Lower Seal Installation Position (below hub flange) . . . . . 7.8 mm (0.31 in.)  
Spindle Lubrication . . . . . 25 hour intervals

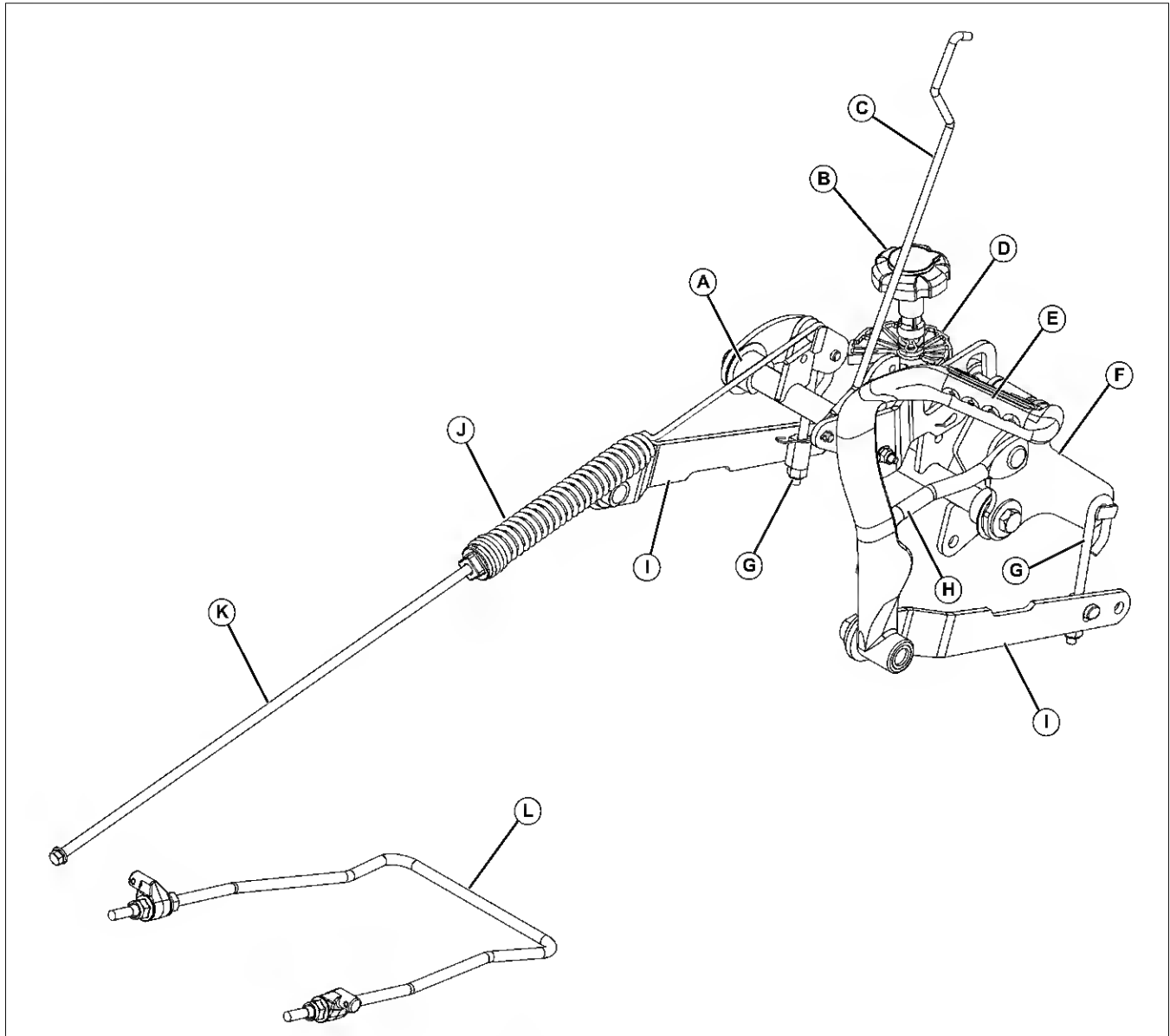
### Special or Required Tools

Tool Name	Tool No.	Tool Use
Blade Height Gauge	AM130907	Use to check mower level

# ATTACHMENTS COMPONENT LOCATION

## Component Location

### Deck Lift Assembly



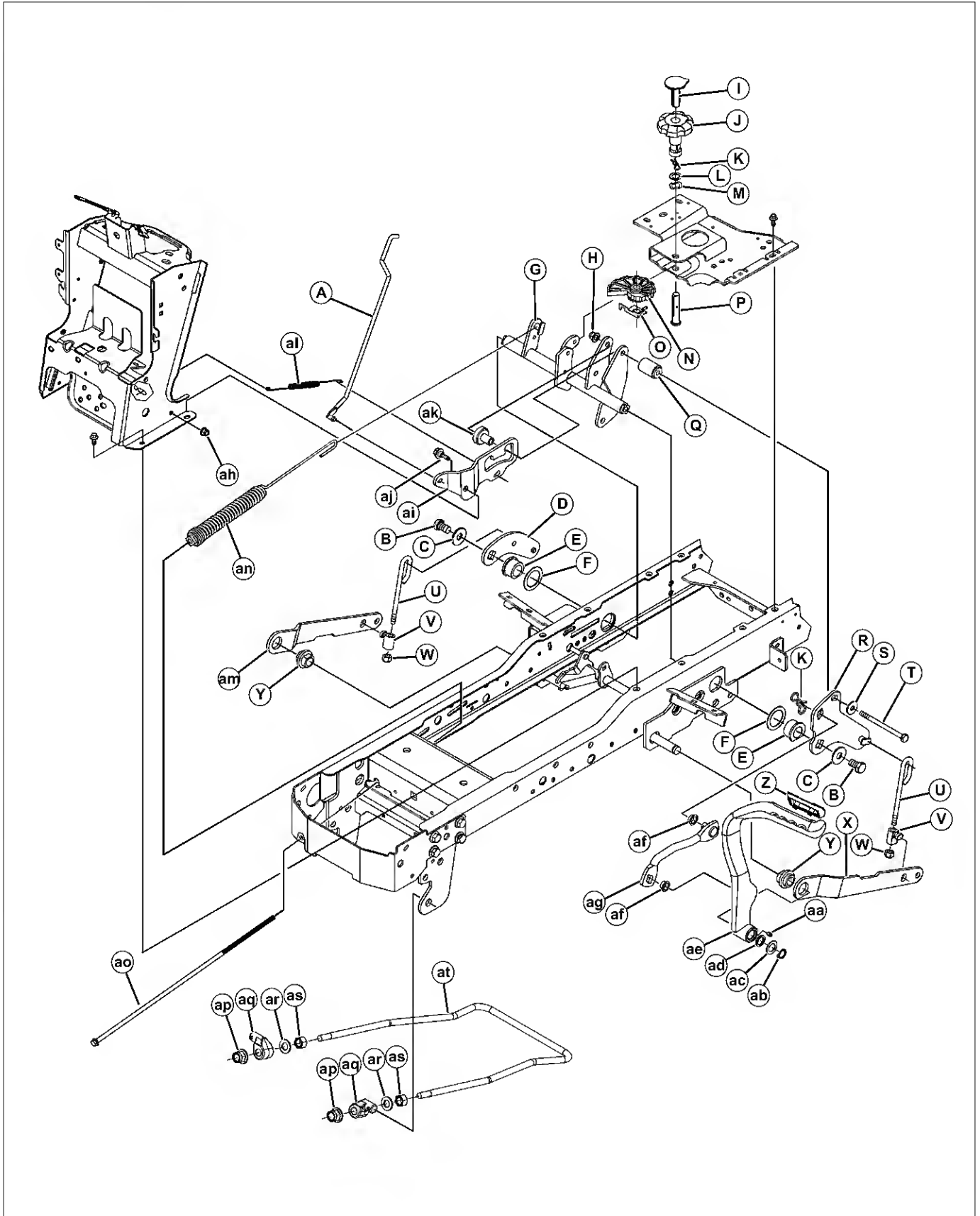
MX36692

L- Front Deck Hanger Assembly

- A- Rockshaft, Lift Pivot Shaft
- B- Deck Cutting Height Adjustment Knob
- C- Deck Lift Lock Rod
- D- Depth Stop Cam
- E- Deck Lift Foot Pedal
- F- Pivot Plate, LH
- G- Draft Link (J Arm)
- H- Link
- I- Lift Arms
- J- Lift Assist Spring (48 and 54 Inch Decks)
- K- Lift Assist Adjustment Screw (48 and 54 Inch Decks)

# ATTACHMENTS COMPONENT LOCATION

## Deck Lift Components





# ATTACHMENTS COMPONENT LOCATION

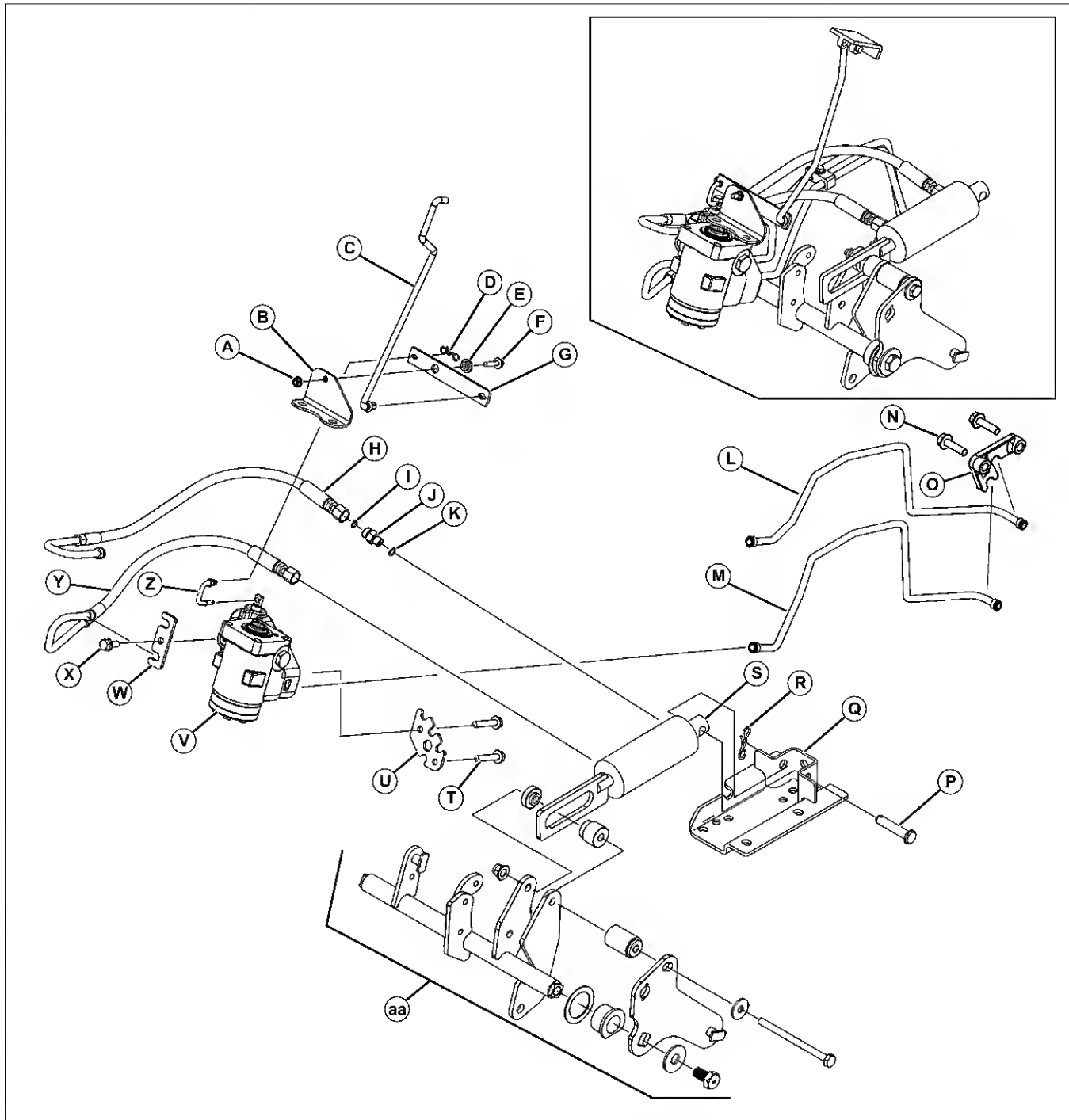
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MX38151

A- Deck Lift Lock Rod  
B- Bolt  
C- Washer  
D- Pivot Plate, RH  
E- Bushing  
F- Washer  
G- Rockshaft Lift Pivot Shaft  
H- Lock Nut M10  
I- Level Gauge  
J- Knob  
K- Spring Pin  
L- Washer 21/32x1x0.06 in.  
M- Wave Washer  
N- Depth Stop Cam  
O- Spring  
P- Pin  
Q- Spacer  
R- Pivot Plate, LH  
S- Washer 10.5x30x2.5 mm  
T- Bolt M10  
U- Draft Link (J-Arm)  
V- Lift Link  
W- Lock Nut  
X- Lift Arm, LH  
Y- Bushing  
Z- Pad (SN -85000)  
AA- Lubrication Fitting  
AB- Snap Ring  
AC- Washer  
AD- Seal  
AE- Pedal  
AF- Bushing  
AG- Link  
AH- Lock Nut M8  
AI- Latch Pivot Arm  
AJ- Screw M10  
AK- Spacer  
AL- Latch Extension Spring  
AM- Lift Arm, RH  
AN- Lift Assist Spring (48 and 54 Inch Decks)  
AO- Adjustment Screw (48 and 54 Inch Decks)  
AP- Lock Nut M12  
AQ- Trunnion  
AR- Washer 13x24x2.5 mm  
AS- Nut M12  
AT- Hanger Bracket

# ATTACHMENTS COMPONENT LOCATION

## Hydraulic Lift Components



MX40441

- A- Nut
- B- Bracket
- C- Lift Control Rod
- D- Spring Pin
- E- Bushing
- F- Bolt
- G- Pivot Bracket
- H- Hydraulic Hose

- I- O-Ring (2 used)
- J- Fitting (2 used)
- K- O-Ring (2 used)
- L- Hydraulic Line
- M- Hydraulic Line
- N- Cap Screw (2used)
- O- Clamp Bracket (to transaxle)
- P- Drilled Pin
- Q- Cylinder Bracket

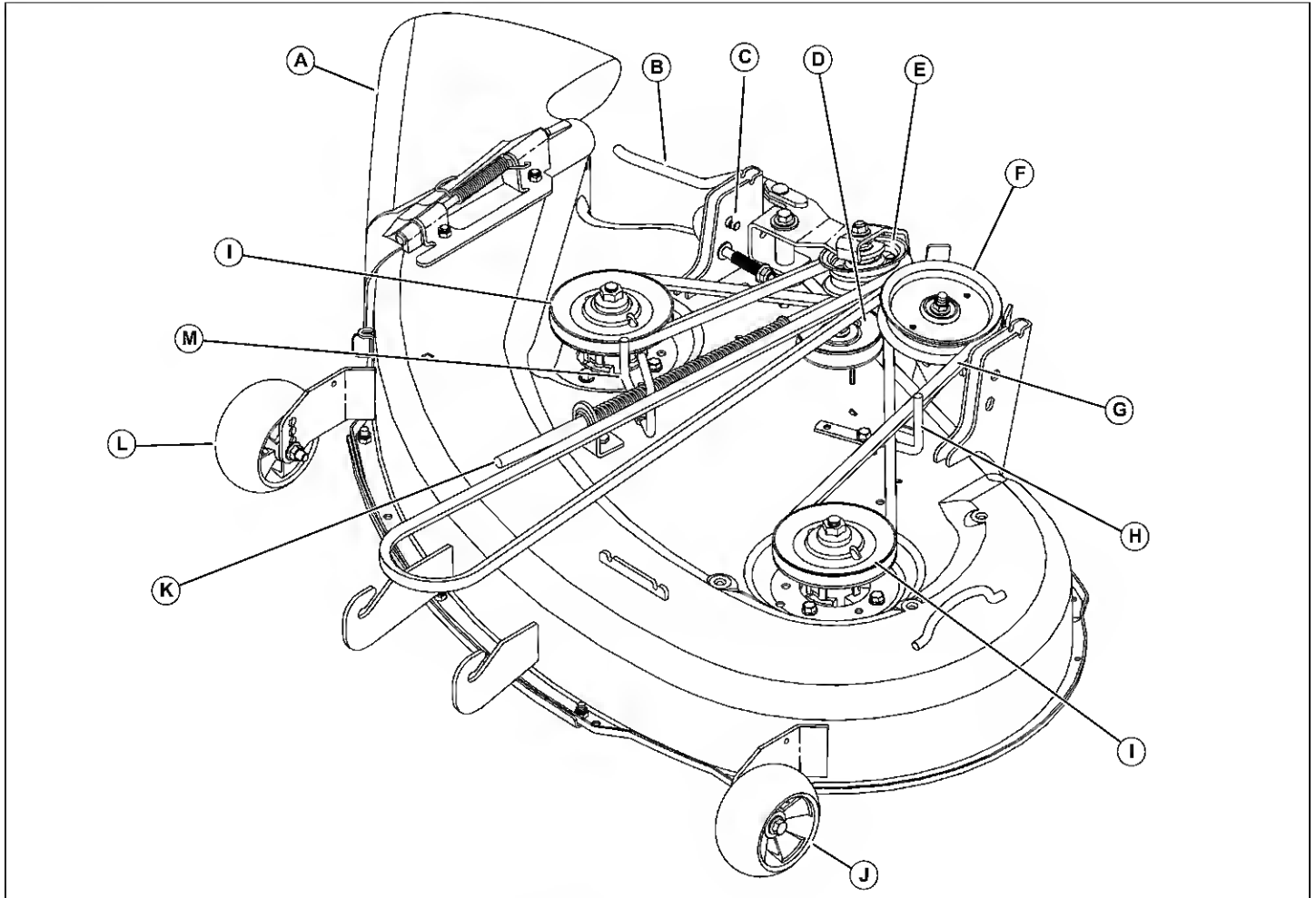
## ATTACHMENTS COMPONENT LOCATION

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R- Spring Pin  
S- Hydraulic Lift Cylinder  
T- Cap Screw (2 used)  
U- Clamp Bracket (to SCU)  
V- Steering Control Unit (SCU)  
W- Clamp Bracket (to SCU)  
X- Cap Screw  
Y- Hydraulic Hose  
Z- Link  
AA- Lift Components (See Attachments section)

## ATTACHMENTS COMPONENT LOCATION

### 38C Mower Deck (SN -020000)



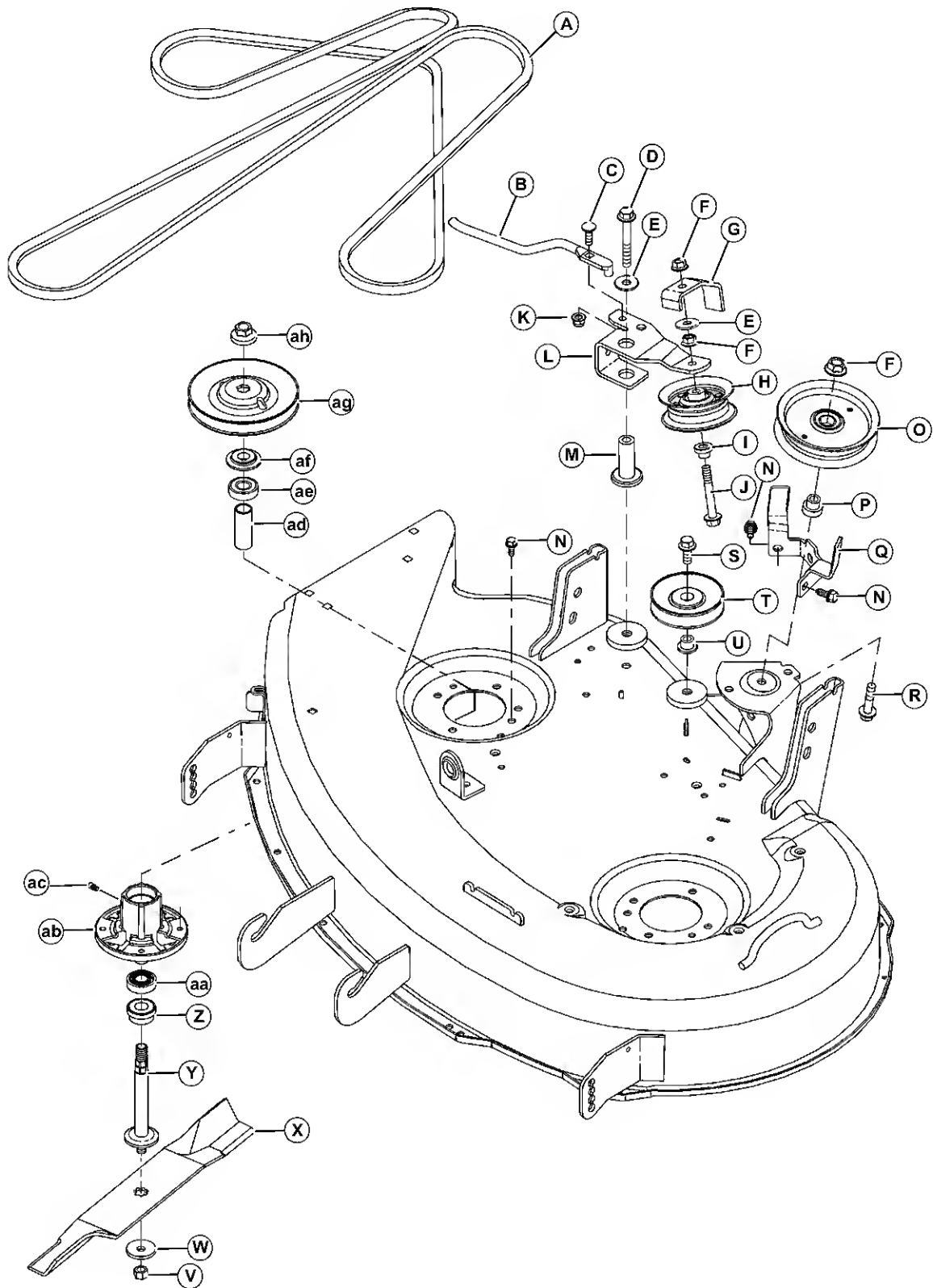
MX37033

**Picture Note: This deck used on machines through SN -040000)**

- A- Discharge Chute
- B- Tension Handle
- C- Deck Mounting "J" Pin (2 used)
- D- Flat Idler Sheave
- E- Tension Idler
- F- Flat Idler
- G- Primary Drive Belt
- H- Belt Guide
- I- Spindle Sheave (2 used)
- J- Gage Wheel (Left Front)
- K- Tension Spring Assembly (Compression)
- L- Gage Wheel (Right Front)
- M- Belt Guide

# ATTACHMENTS COMPONENT LOCATION

## Idlers and Sheaves - 38C Deck (SN -020000)



## ATTACHMENTS COMPONENT LOCATION

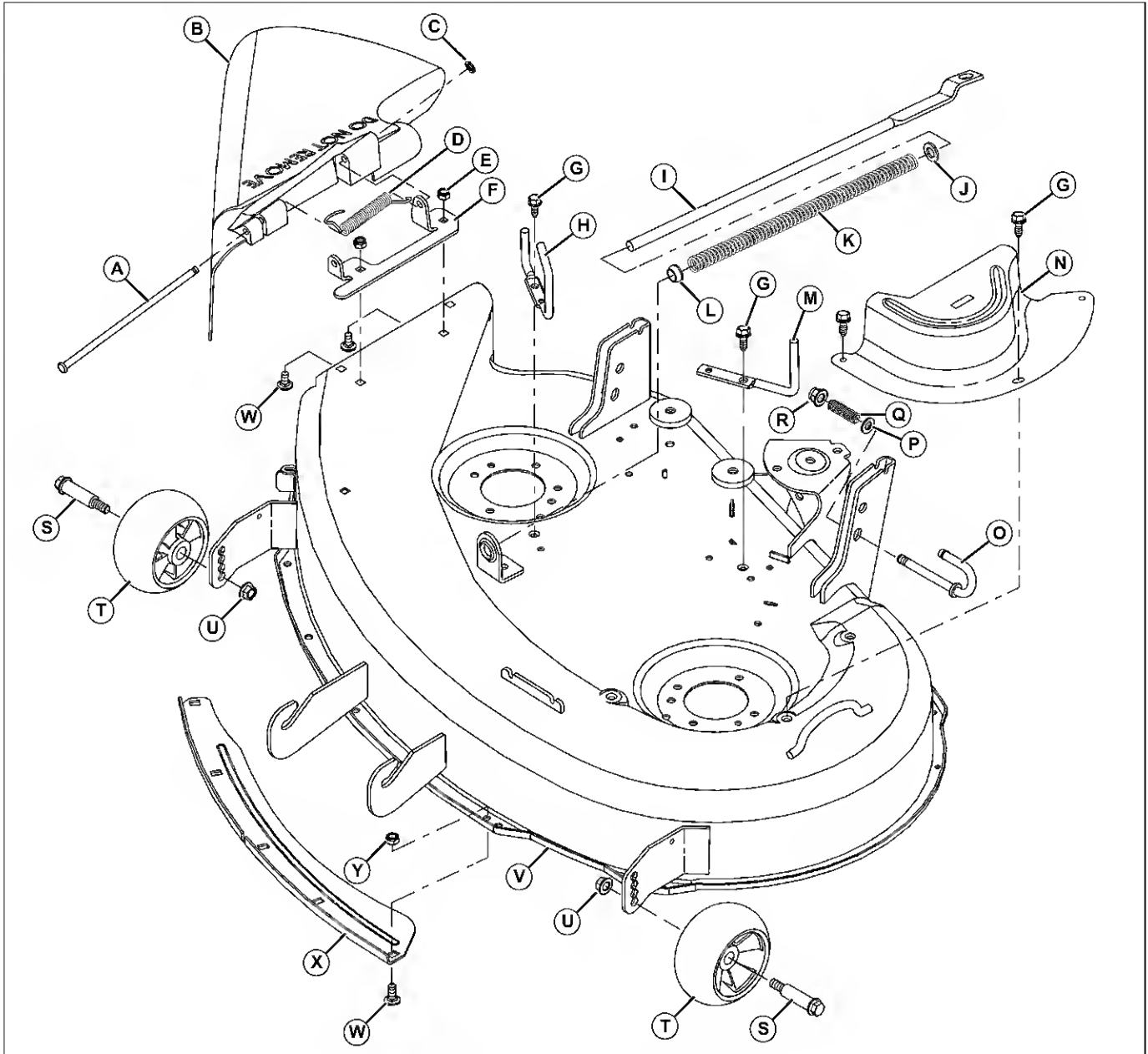
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MX37034

A- Belt  
B- Idler Tensioning Handle  
C- Bolt M8x25  
D- Screw M10x80  
E- Washer 10.50x30x2.50 mm (2 used)  
F- Flange Nut M10 (2 used)  
G- Belt Guide  
H- Idler Sheave  
I- Bushing  
J- Screw M10x70  
K- Lock Nut M8  
L- Arm  
M- Bushing  
N- Screw (11 used)  
O- Sheave Assembly  
P- Bushing  
Q- Belt Guide  
R- Screw M10x45  
S- Screw M10x25  
T- Idler Sheave  
U- Bushing  
V- Nut (2 used)  
W- Washer (2 used)  
X- Blade (2 used)  
Y- Spindle (2 used)  
Z- Spacer (2 used)  
AA- Ball Bearing (2 used)  
AB- Blade Spindle (2 used)  
AC- Grease Fitting (2 used)  
AD- Spacer (2 used)  
AE- Ball Bearing (2 used)  
AF- Spacer (2 used)  
AG- Spindle Sheave (2 used)  
AH- Spindle Nut (2 used)

# ATTACHMENTS COMPONENT LOCATION

Shields - 38C Deck (SN -020000)



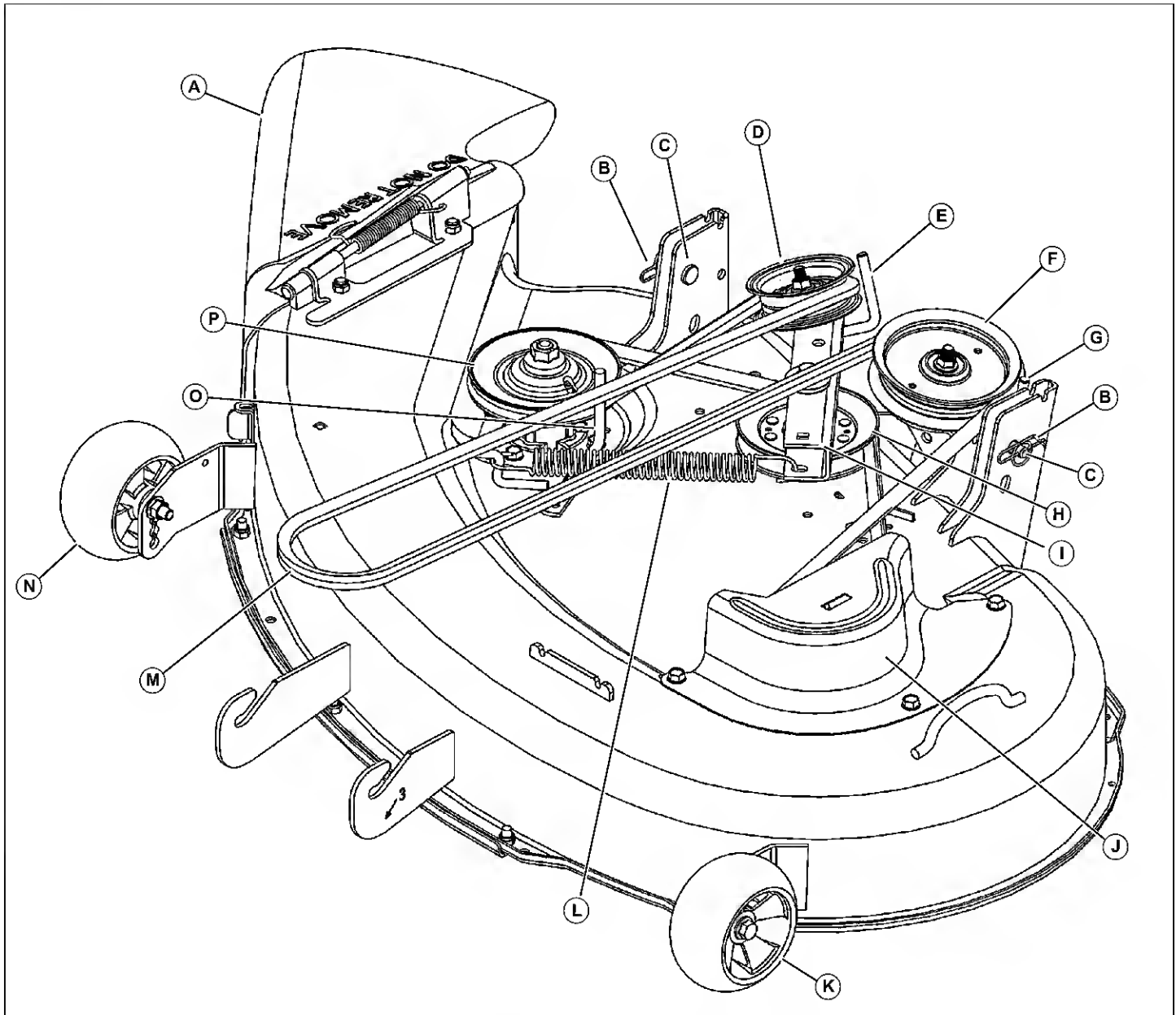
MX370354

- A- Pin
- B- Chute
- C- Push Nut
- D- Torsion Spring
- E- Lock Nut M8 (2 used)
- F- Hinge
- G- Screw
- H- Belt Guide
- I- Tension Rod
- J- Washer 13x24x2.50 mm
- K- Compression Spring
- L- Ball

- M- Belt Guide
- N- Belt Shield
- O- Deck Mounting "J" Pin (2 used)
- P- Washer 10.50x20x2 mm (2 used)
- Q- Compression Spring (2 used)
- R- Lock Nut M10 (2 used)
- S- Screw
- T- Gage Wheel
- U- Flange Nut M10
- V- Deck
- W- Bolt M8x20 (5 used)
- X- Lip Section
- Y- Lock Nut M8 (3 used)

# ATTACHMENTS COMPONENT LOCATION

## 38C Mower Deck (SN 020001-)



MX37979

**Picture Note: This deck used on machines starting SN 040001-)**

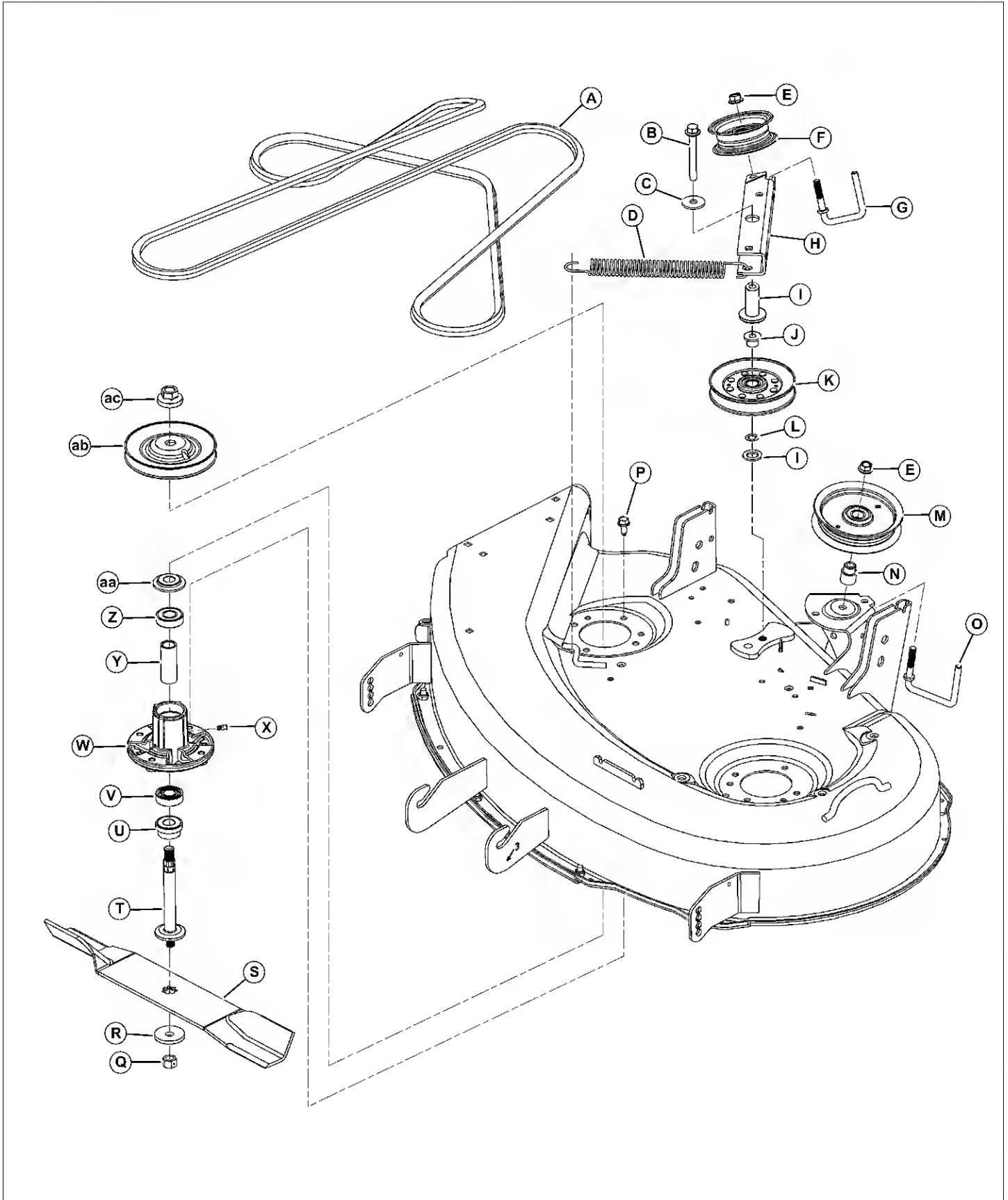
- A- Discharge Chute
- B- Spring Pin (2 used)
- C- Drilled Pin (2 used)
- D- Tension Idler Sheave
- E- Belt Guide
- F- Idler Sheave
- G- Belt Guide
- H- Idler Sheave
- I- Pivot/Mounting Arm
- J- Belt Shield

- K- Gage Wheel (Left)
- L- Tension Spring (Extension)
- M- Drive Belt
- N- Gage Wheel (Right)
- O- Belt Guide
- P- Spindle Sheave (2 used)



# ATTACHMENTS COMPONENT LOCATION

## Idlers and Sheaves - 38C Deck (SN 020001-)



## ATTACHMENTS COMPONENT LOCATION

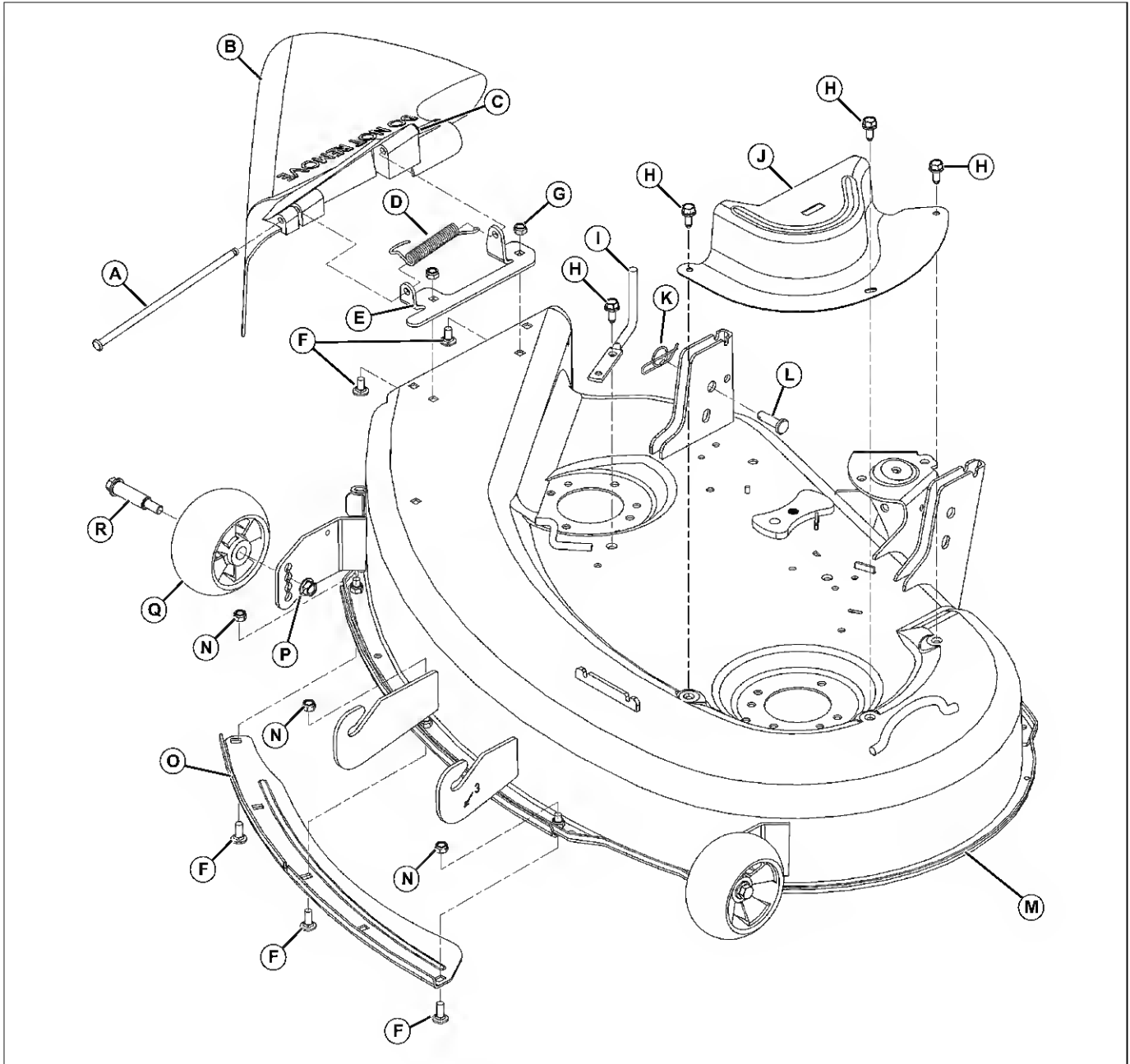
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MX37856

A- Belt  
B- Screw M10x80  
C- Spacer Washer  
D- Tensioning Spring  
E- Flange Nut M10  
F- Idler Sheave  
G- Sheave Mounting Bolt/Belt Guide  
H- Pivot/Mounting Arm  
I- Washer 10.50x30x2.50 mm  
J- Bushing  
K- Sheave Assembly  
L- Lock Washer  
M- Idler Sheave  
N- Bushing  
O- Sheave Mounting Bolt/Belt Guide  
P- Screw (8 used)  
Q- Lock Nut M8  
R- Washer (2 used)  
S- Blade (2 used)  
T- Blade Spindle (2 used)  
U- Spacer (2 used)  
V- Ball Bearing (2 used)  
W- Spindle Housing (2 used)  
X- Grease Fitting (2 used)  
Y- Spacer (2 used)  
Z- Ball Bearing (2 used)  
AA- Spacer (2 used)  
AB- Spindle Sheave (2 used)  
AC- Spindle Nut (2 used)

# ATTACHMENTS COMPONENT LOCATION

Shields - 38C Deck (SN 020001-)



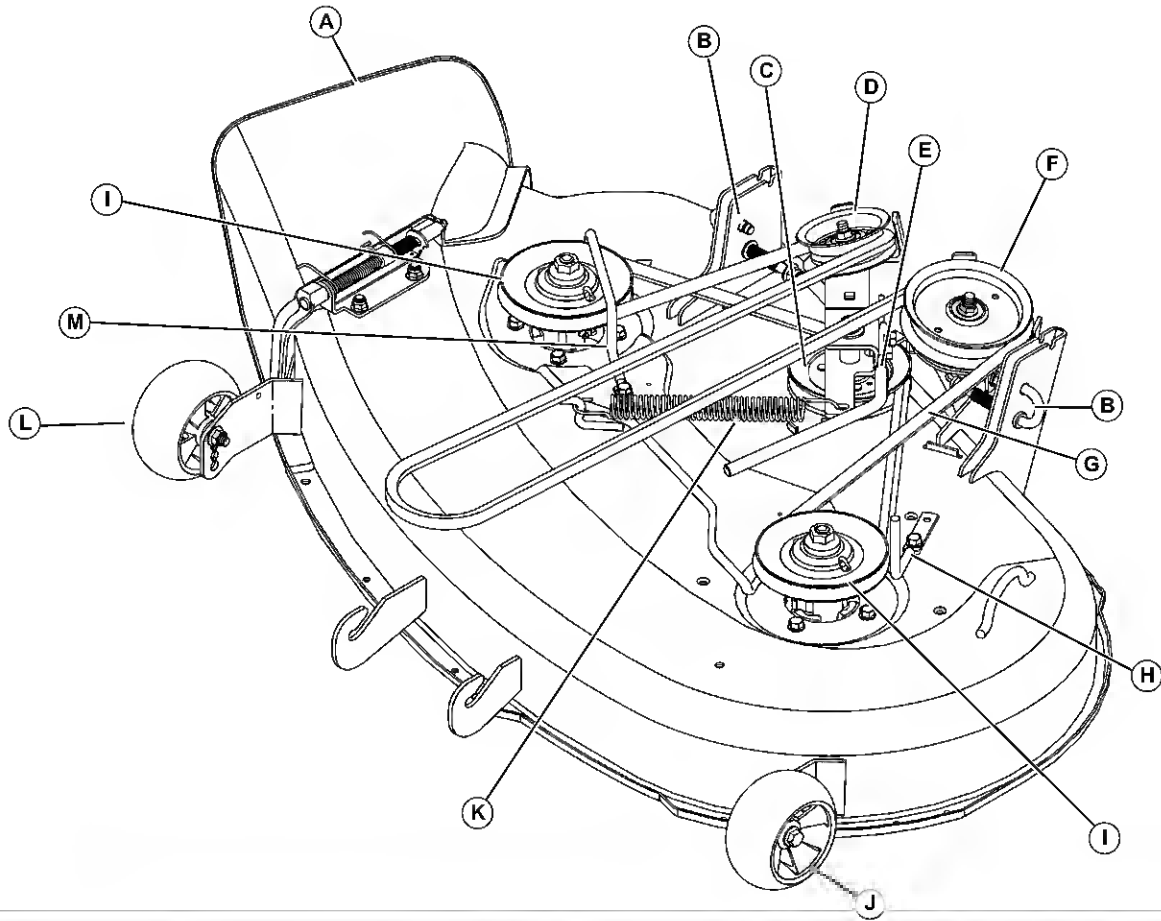
MX37978

- A- Pin
- B- Chute
- C- Push Nut
- D- Torsion Spring
- E- Hinge
- F- Bolt M8x20 (5 used)
- G- Lock Nut M8 (2 used)
- H- Screw (4 used)
- I- Belt Guide
- J- Belt Shield
- K- Spring Pin (2 used)

- L- Drilled Pin (2 used)
- M- Deck
- N- Lock Nut M8 (3 used)
- O- Lip Section
- P- Flange Nut M10 (2 Used)
- Q- Gage Wheel (2 Used)
- R- Shoulder Bolt M10 (2 Used)

## ATTACHMENTS COMPONENT LOCATION

### 42C Mower Deck (SN -020000)

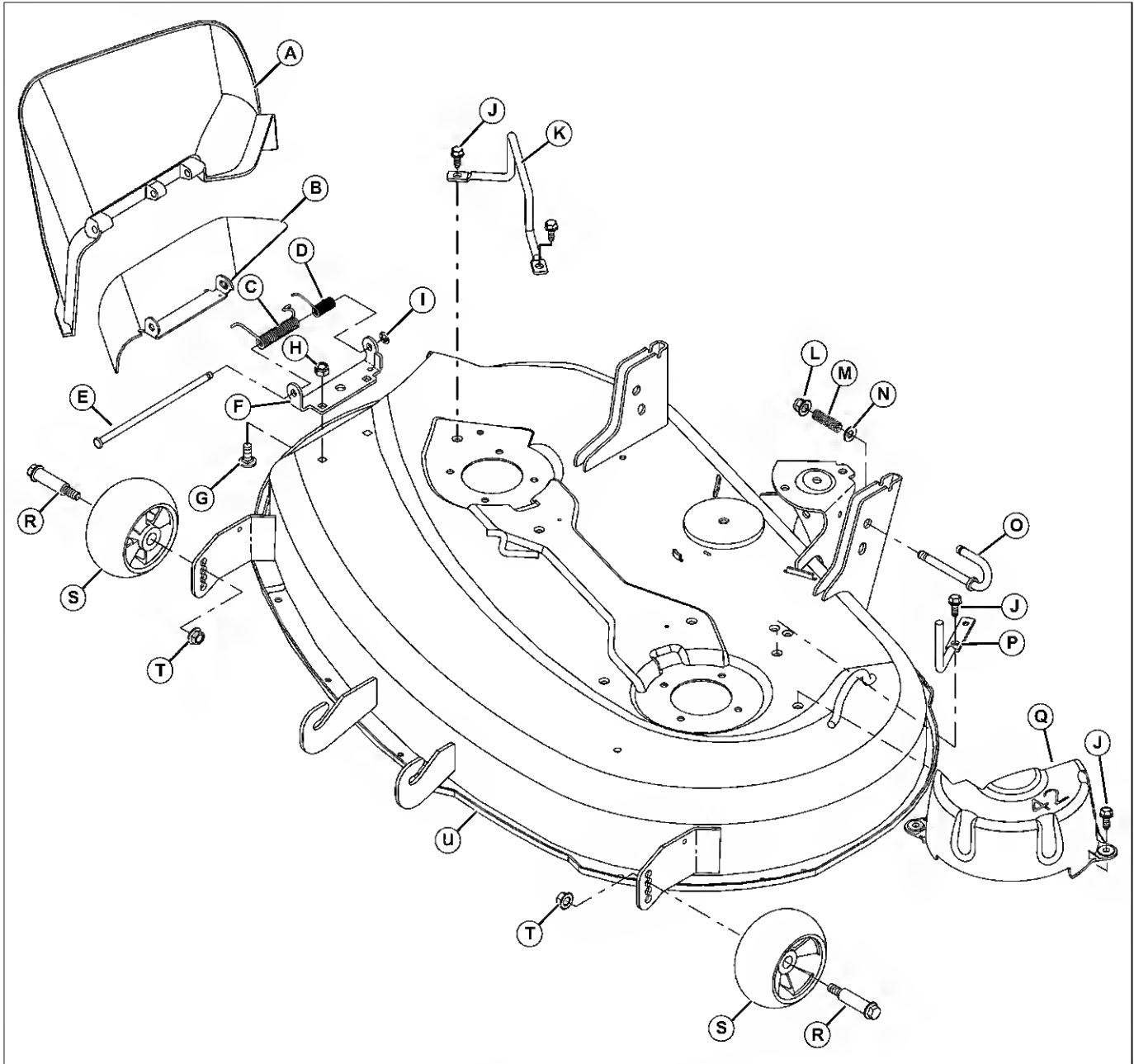


MX36036

- A- Discharge Chute
- B- Deck Mounting "J" Pin
- C- Flat Idler Sheave
- D- Tension Idler
- E- Tension Handle
- F- Flat Idler
- G- Primary Drive Belt
- H- Belt Guide
- I- Spindle Sheave (2 used)
- J- Gage Wheel (Left Front)
- K- Tension Spring Assembly
- L- Gage Wheel (Right Front)
- M- Belt Guide

# ATTACHMENTS COMPONENT LOCATION

Shields - 42C Deck (SN -020000)



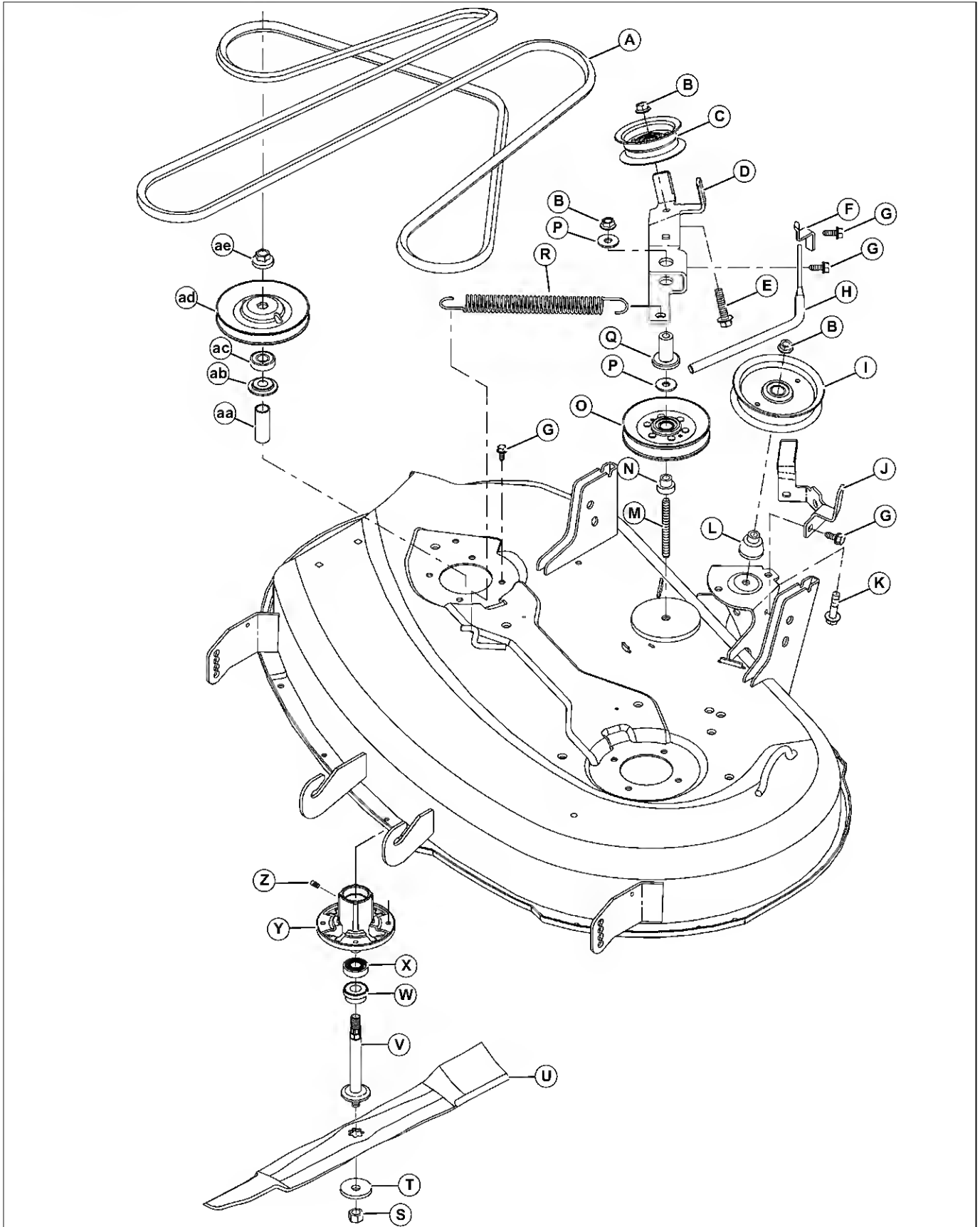
MX37038

- A- Guard
- B- Chute
- C- Torsion Spring
- D- Torsion Spring
- E- Pin
- F- Hinge
- G- Bolt M8x20 (2 used)
- H- Lock Nut M8 (2 used)
- I- Push Nut
- J- Screw
- K- Belt Guide

- L- Lock Nut M10 (2 used)
- M- Compression Spring (2 used)
- N- Washer 10.50x20x2 mm (2 used)
- O- Deck Mounting "J" Pin (2 used)
- P- Belt Guide
- Q- Belt Shield
- R- Screw
- S- Gage Wheel
- T- Flange Nut M10
- U- Deck

# ATTACHMENTS COMPONENT LOCATION

## Idlers and Sheaves - 42C Deck (SN -020000)



## ATTACHMENTS COMPONENT LOCATION

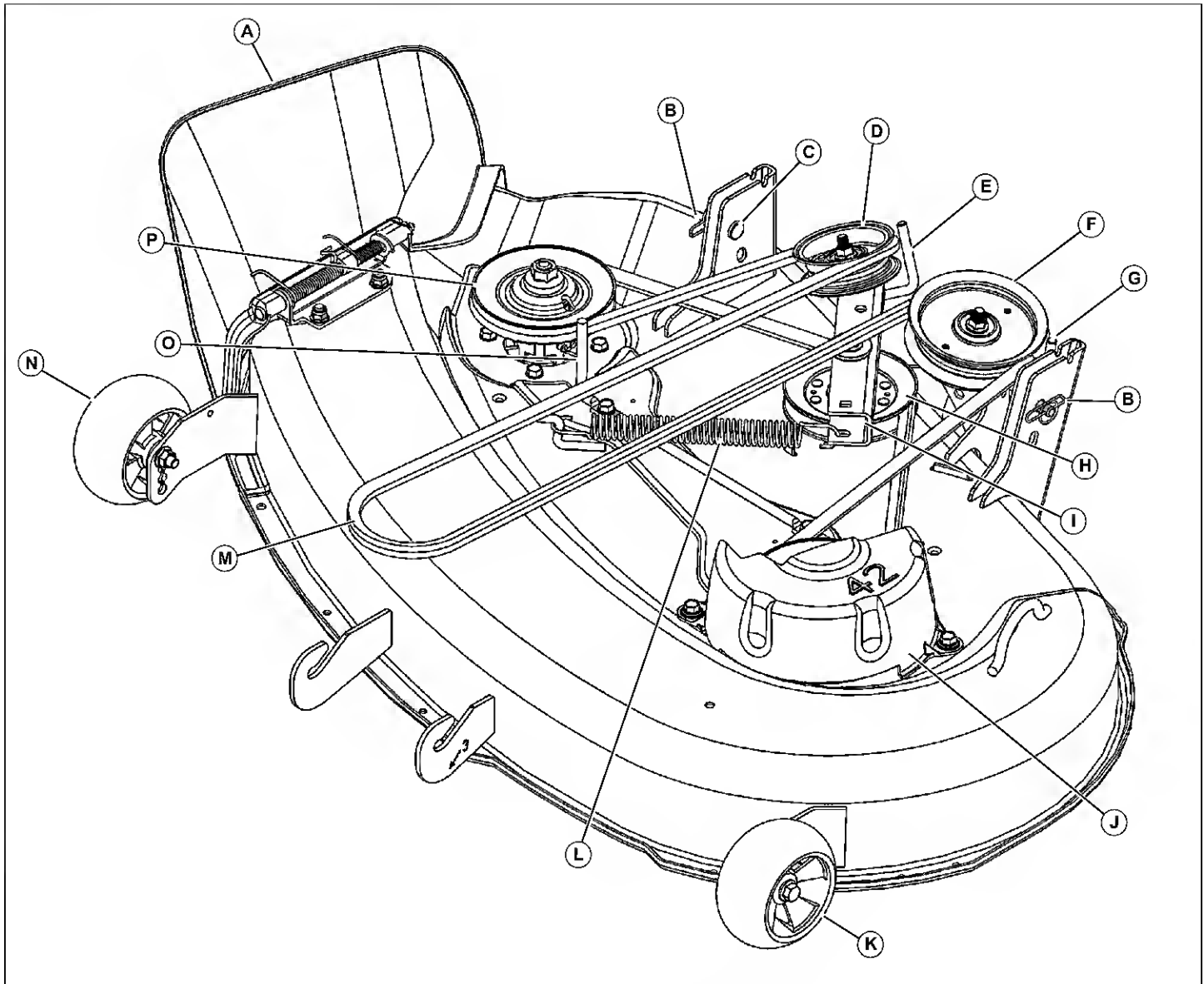
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MX37037

A- Belt  
B- Flange Nut M10 (3 used)  
C- Idler Sheave  
D- Arm  
E- Cap Screw M10x40  
F- Belt Guide  
G- Screw (8 used)  
H- Idler Tensioning Handle  
I- Idler Sheave  
J- Belt Guide  
K- Screw M10x60  
L- Bushing  
M- Stud  
N- Bushing  
O- Sheave Assembly  
P- Washer 10.50x30x2.50 mm (2 used)  
Q- Bushing  
R- Extension Spring  
S- Lock Nut (2 used)  
T- Washer (2 used)  
U- Blade (2 used)  
V- Blade Spindle (2 used)  
W- Spacer (2 used)  
X- Ball Bearing (2 used)  
Y- Spindle Housing (2 used)  
Z- Grease Fitting (2 used)  
AA- Spacer (2 used)  
AB- Spacer (2 used)  
AC- Ball Bearing (2 used)  
AD- Spindle Sheave (2 used)  
AE- Spindle Nut (2 used)

## ATTACHMENTS COMPONENT LOCATION

### 42C Mower Deck (SN 020001-)



MX37981

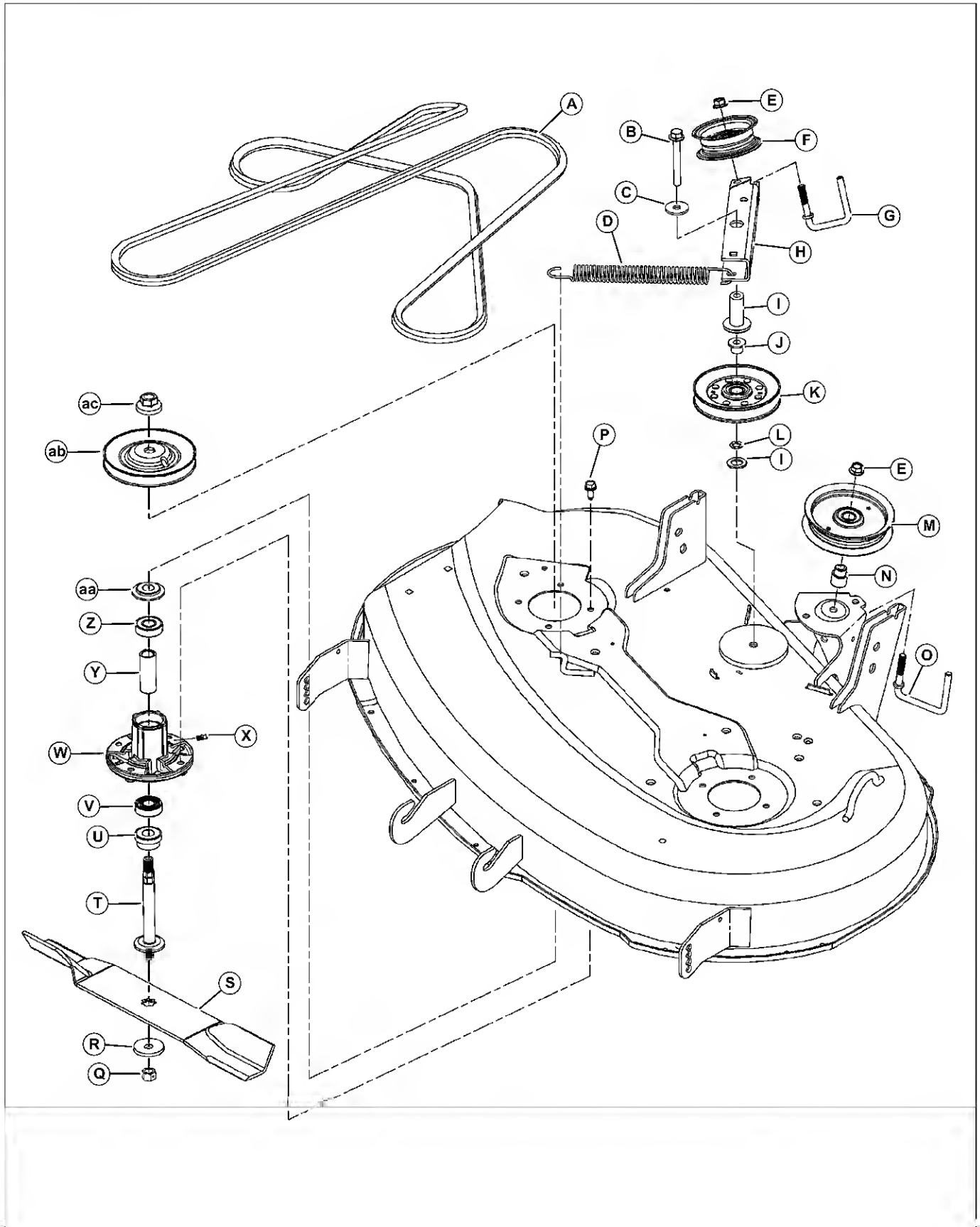
- A- Discharge Chute
- B- Spring Pin (2 used)
- C- Drilled Pin (2 used)
- D- Tension Idler Sheave
- E- Belt Guide
- F- Flat Idler Sheave
- G- Belt Guide
- H- Idler Sheave
- I- Pivot/Mounting Arm
- J- Belt Shield
- K- Gage Wheel (Left)
- L- Tension Spring
- M- Drive Belt
- N- Gage Wheel (Right)

- O- Belt Guide
- P- Spindle Sheave (2 used)



# ATTACHMENTS COMPONENT LOCATION

Idlers and Sheaves - 42C Deck (SN 020001-)



## ATTACHMENTS COMPONENT LOCATION

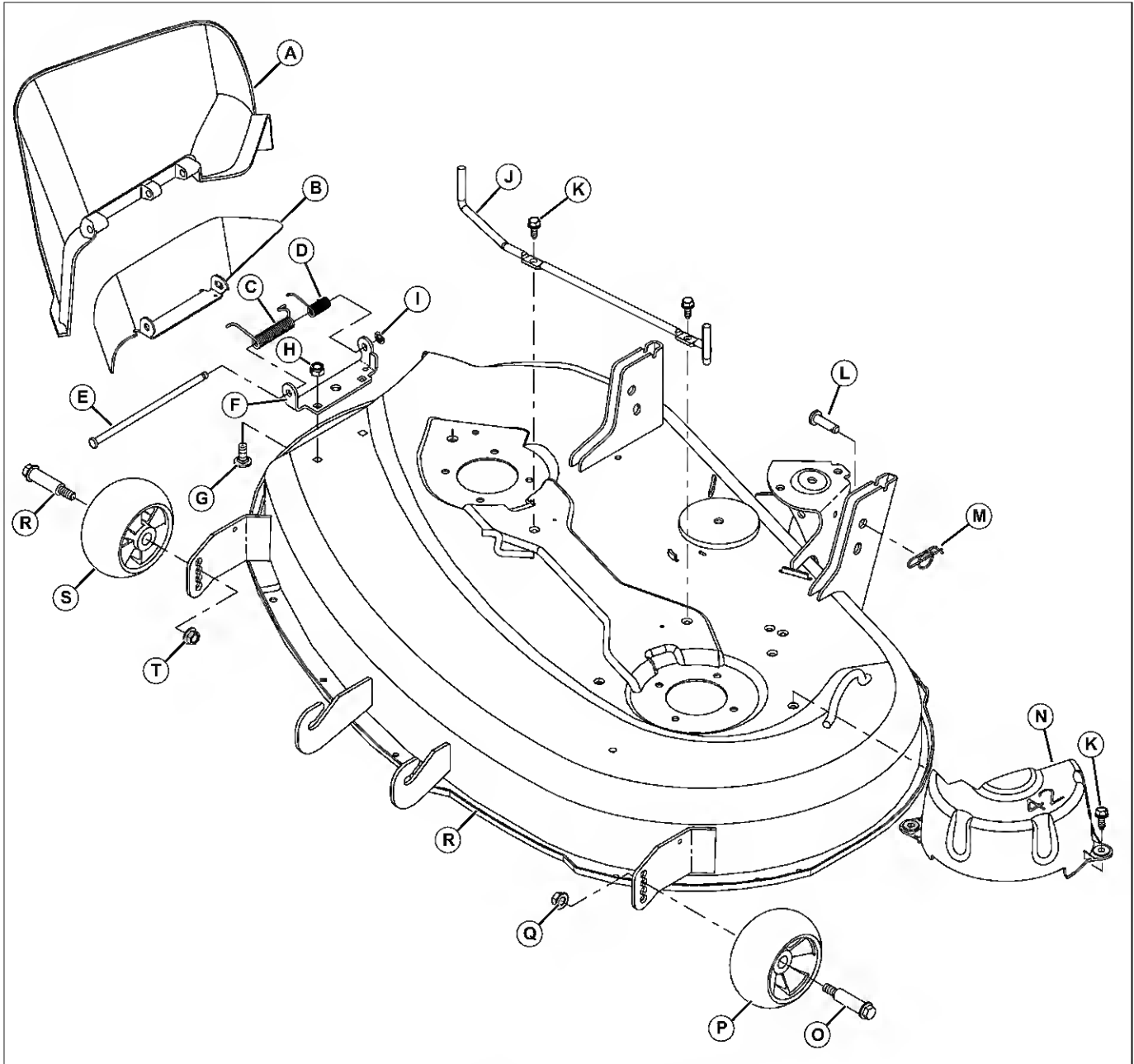
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MX38153

A- Belt  
B- Screw M10x80  
C- Spacer Washer  
D- Tensioning Spring  
E- Flange Nut M10  
F- Idler Sheave  
G- Sheave Mounting Bolt/Belt Guide  
H- Pivot/Mounting Arm  
I- Washer 10.50x30x2.50 mm  
J- Bushing  
K- Sheave Assembly  
L- Lock Washer  
M- Idler Sheave  
N- Bushing  
O- Sheave Mounting Bolt/Belt Guide  
P- Screw (8 used)  
Q- Lock Nut M8  
R- Washer (2 used)  
S- Blade (2 used)  
T- Blade Spindle (2 used)  
U- Spacer (2 used)  
V- Ball Bearing (2 used)  
W- Spindle Housing (2 used)  
X- Grease Fitting (2 used)  
Y- Spacer (2 used)  
Z- Ball Bearing (2 used)  
AA- Spacer (2 used)  
AB- Spindle Sheave (2 used)  
AC- Spindle Nut (2 used)

# ATTACHMENTS COMPONENT LOCATION

Shields - 42C Deck (SN 020001-)



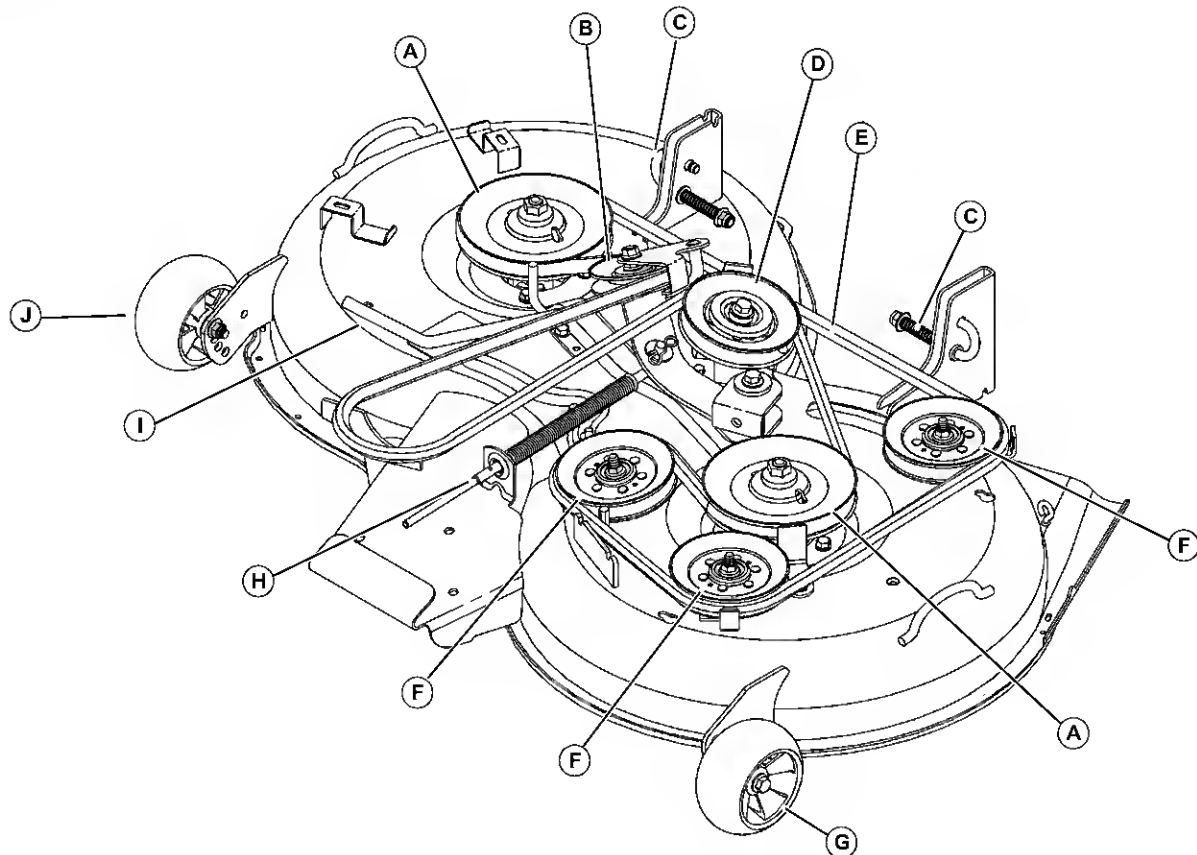
MX38152

- A- Guard
- B- Chute
- C- Torsion Spring
- D- Torsion Spring
- E- Pin
- F- Hinge
- G- Bolt M8x20 (2 used)
- H- Lock Nut M8 (2 used)
- I- Push Nut
- J- Belt Guide
- K- Screw

- L- Drilled Pin (2 used)
- M- Spring Pin (2 used)
- N- Belt Shield
- O- Screw
- P- Gage Wheel
- Q- Flange Nut M10
- R- Deck

## ATTACHMENTS COMPONENT LOCATION

### 42M Mower Deck

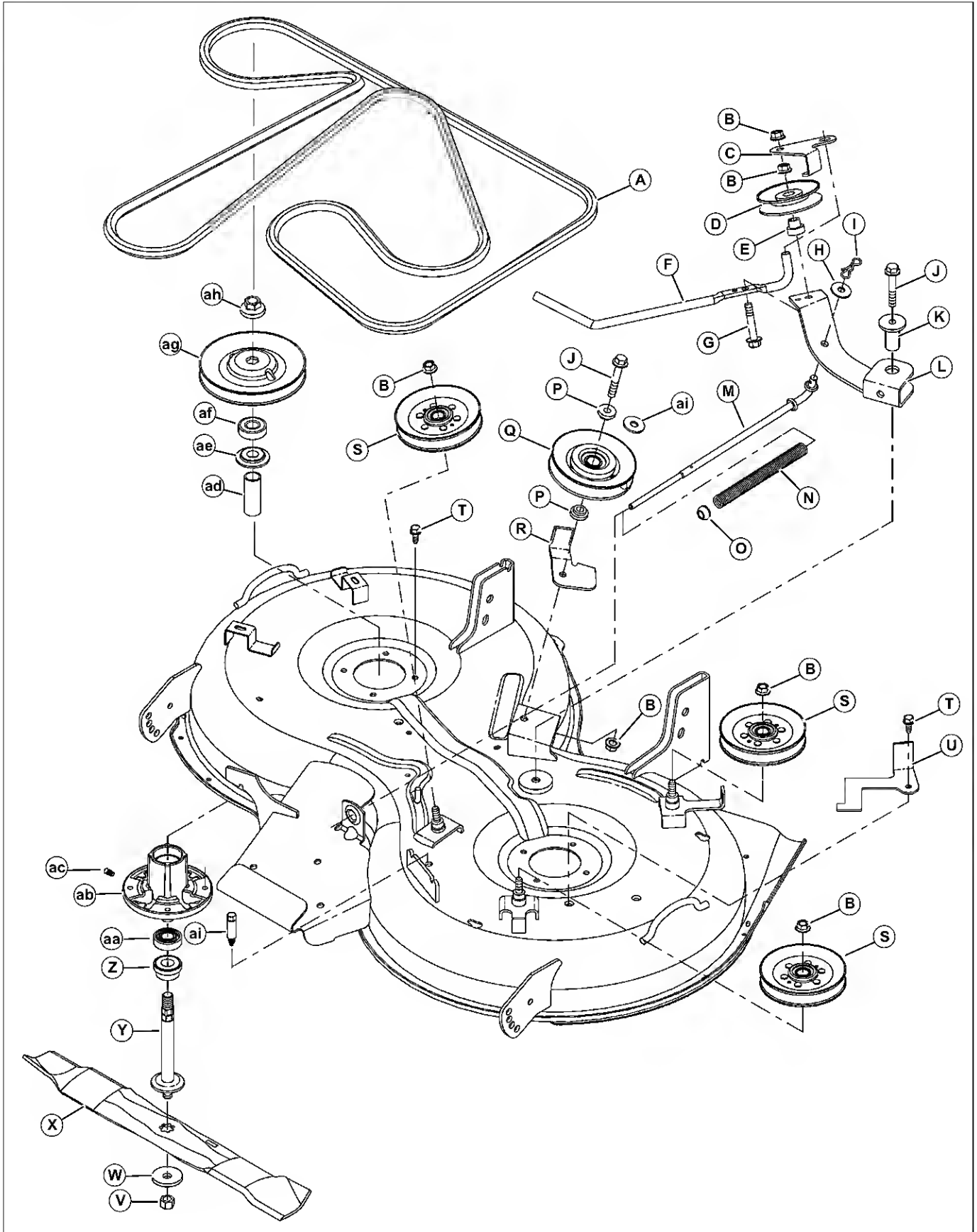


MX36039

- A- Spindle Sheave (2 used)
- B- Tension Idler
- C- Deck Mounting "J" Pin (2 used)
- D- Flat Idler Sheave
- E- Drive Belt
- F- Flat Idler Sheave (3 used)
- G- Gage Wheel (Left Front)
- H- Tension Spring Assembly
- I- Tension Handle
- J- Gage Wheel (Right Front)

# ATTACHMENTS COMPONENT LOCATION

## Idlers and Sheaves - 42M Deck (SN -085000)



# ATTACHMENTS COMPONENT LOCATION

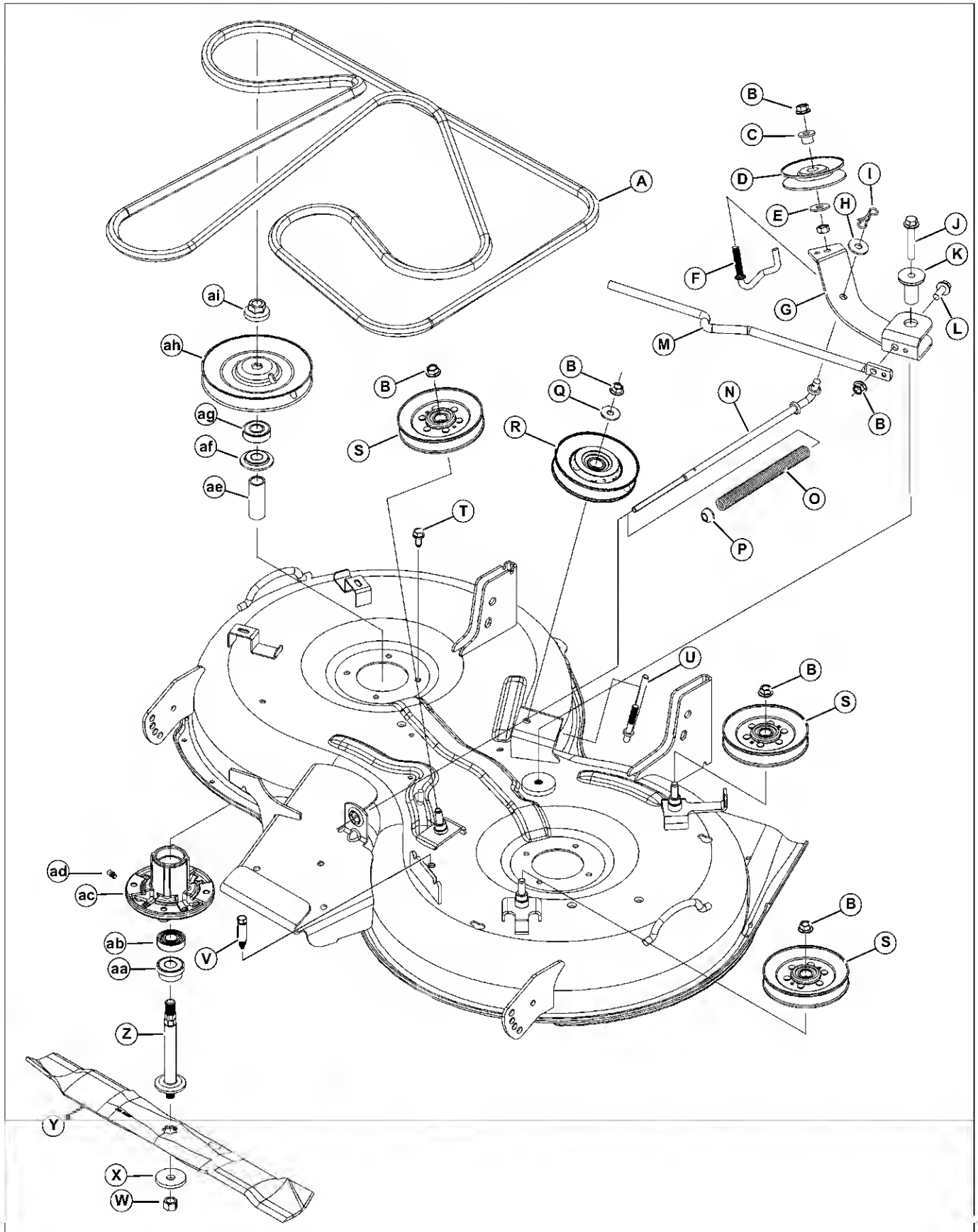
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MX38149

A- Belt  
B- Flange Nut M10 (6 used)  
C- Belt Guide  
D- Idler Sheave  
E- Bushing  
F- Idler Tensioning Handle  
G- Cap Screw M10x55  
H- Washer 10.50x30x2.50 mm  
I- Spring Locking Pin  
J- Screw M10x60 (2 used)  
K- Bushing  
L- Arm  
M- Rod  
N- Compression Spring  
O- Ball  
P- Bushing (SN -20000) (2 used)  
Q- Idler Sheave (changes at SN 20001)  
R- Belt Guide  
S- Idler Sheave (3 used)  
T- Screw (9 used)  
U- Guide  
V- Lock Nut (2 used)  
W- Washer (2 used)  
X- Blades (Left and Right)  
Y- Blade Spindle (2 used)  
Z- Spacer (2 used)  
AA- Ball Bearing (2 used)  
AB- Spindle Housing (2 used)  
AC- Grease Fitting (2 used)  
AD- Spacer (2 used)  
AE- Spacer (2 used)  
AF- Ball Bearing (2 used)  
AG- Spindle Sheave (2 used)  
AH- Spindle Nut (2 used)  
AI- Stud (SN 20001-)  
AJ- Washer (SN 20001-)

# ATTACHMENTS COMPONENT LOCATION

## Idlers and Sheaves - 42M Deck (SN 085001-)



## ATTACHMENTS COMPONENT LOCATION

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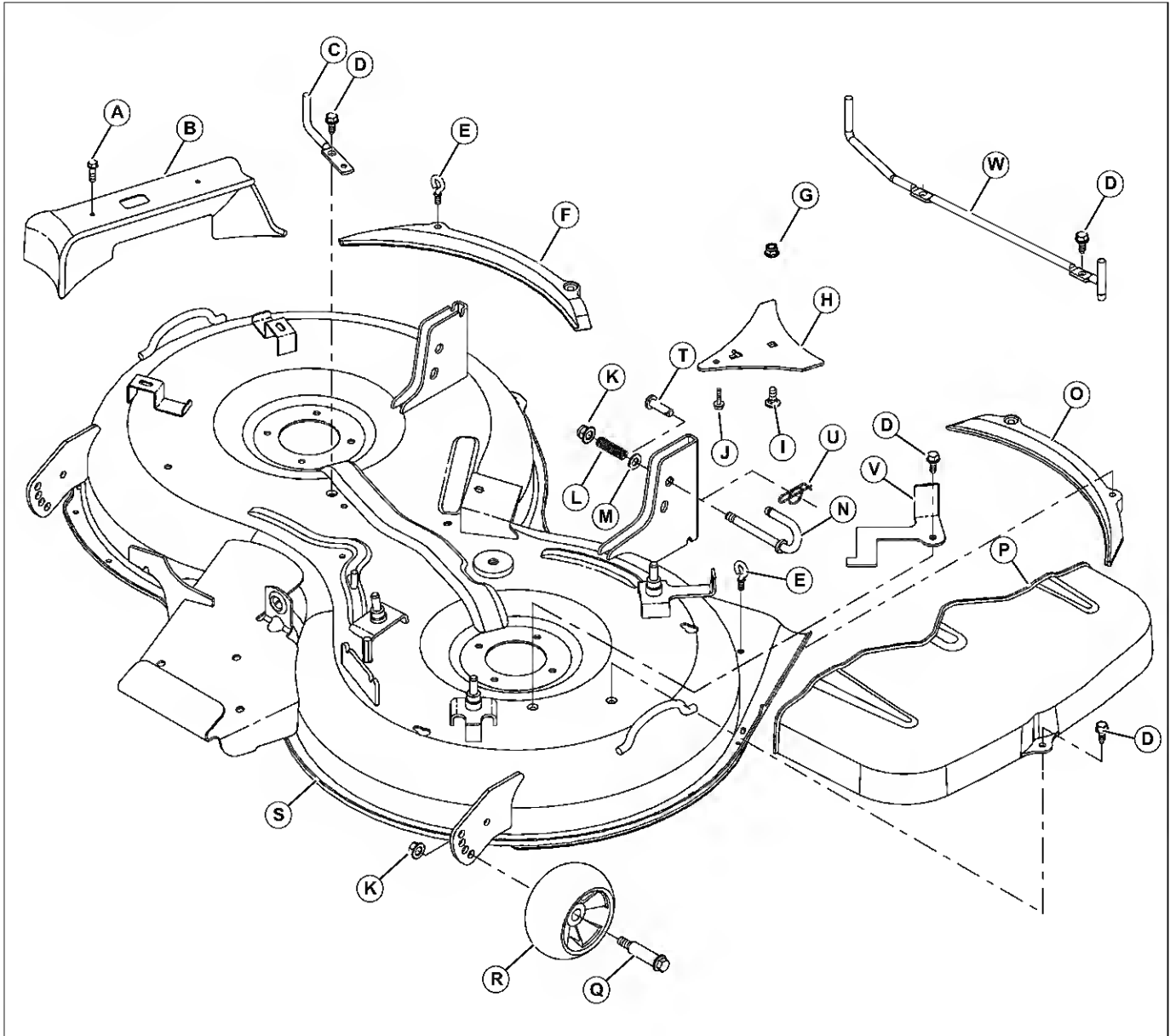
MX40152

A- Belt  
B- Flange Nut M10 (6 used)  
C- Bushing  
D- Idler Sheave  
E- Washer  
F- U-Bolt  
G- Arm  
H- Washer 10.50x30x2.50 mm  
I- Spring Locking Pin  
J- Screw M10x60 (2 used)  
K- Bushing  
L- Bolt  
M- Idler Tensioning Handle  
N- Rod  
O- Compression Spring  
P- Ball  
Q- Washer  
R- Idler Sheave  
S- Idler Sheave (3 used)  
T- Screw (9 used)  
U- U-Bolt  
V- Stud  
W- Lock Nut (2 used)  
X- Washer (2 used)  
Y- Blades (Left and Right)  
Z- Blade Spindle (2 used)  
AA- Spacer (2 used)  
AB- Ball Bearing (2 used)  
AC- Spindle Housing (2 used)  
AD- Grease Fitting (2 used)  
AE- Spacer (2 used)  
AF- Spacer (2 used)  
AG- Ball Bearing (2 used)  
AH- Spindle Sheave (2 used)  
AI- Spindle Nut (2 used)



# ATTACHMENTS COMPONENT LOCATION

## Shields - 42M Deck

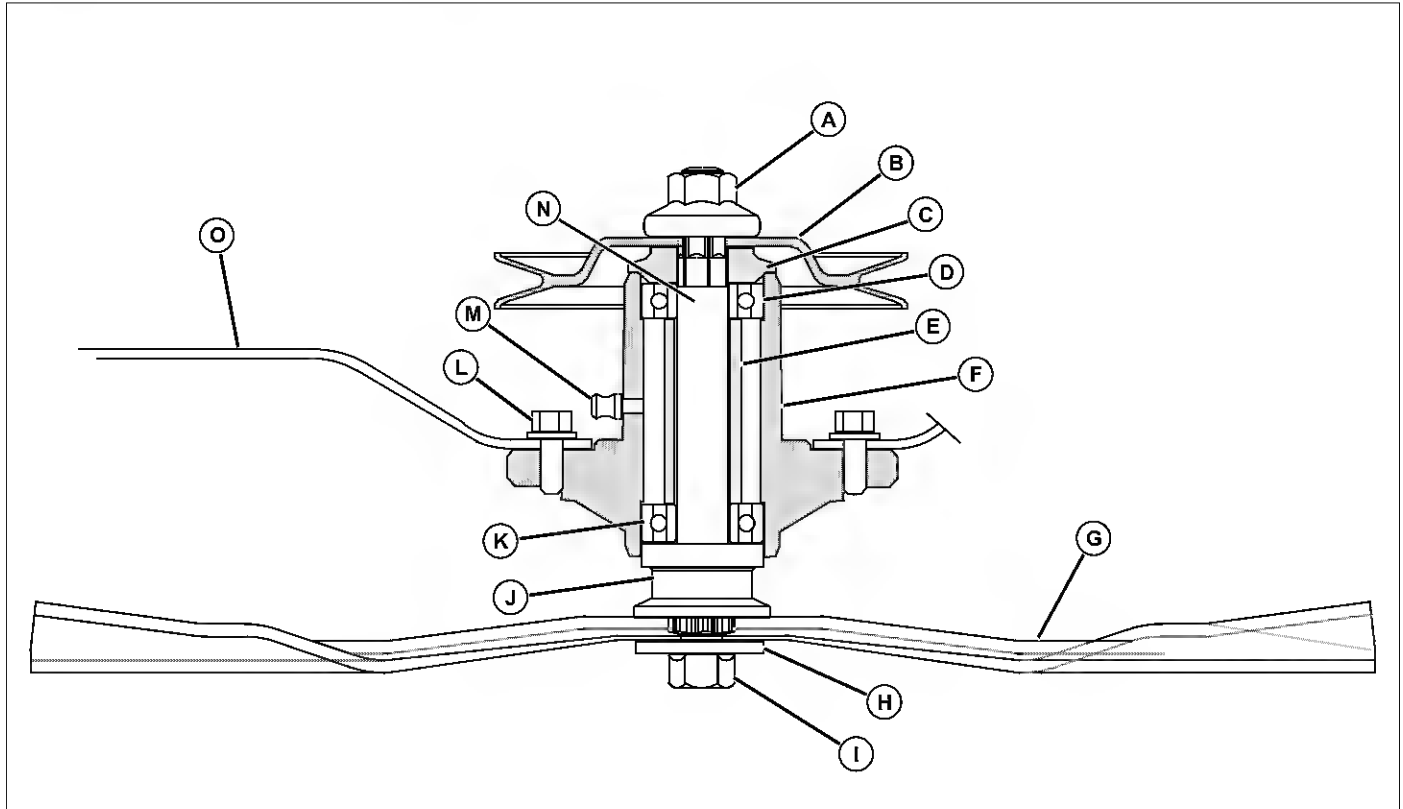


MX38150A

- |  |   |
|--|---|
| A- Screw (2 used)                            | N- "J" Pin (SN -20000) (2 used)         |
| B- Deflector                                 | O- Insert, RH Mulch                     |
| C- Belt Guide                                | P- Belt Shield                          |
| D- Screw (3 used)                            | Q- Screw (2 used)                       |
| E- Eyebolt (2 used)                          | R- Gage Wheel (2 used)                  |
| F- Insert, LH Mulch                          | S- Deck                                 |
| G- Lock Nut M8                               | T- Pin (SN 20001-) (2 used)             |
| H- Retainer                                  | U- Clip (SN 20001-) (2 used)            |
| I- Bolt M8x20                                | V- Belt Guide                           |
| J- Screw                                     | W- Belt Guide (replaces Guides C and V) |
| K- Flange Nut M10 (SN -20000) (4 used)       |   |
| L- Compression Spring (SN -20000) (2 used)   |   |
| M- Washer 10.50x20x2 mm (SN -20000) (2 used) |   |

## ATTACHMENTS COMPONENT LOCATION

### Spindles All 38 and 42 Decks -MY09



MIF

- A- Spindle Sheave Nut
- B- Spindle Sheave
- C- Upper Seal Ring
- D- Upper Bearing
- E- Spacer
- F- Spindle Housing
- G- Blade
- H- Washer
- I- Blade Nut (12mm)
- J- Spacer
- K- Lower Bearing
- L- Cap Screw (4 used)
- M- Lubrication Fitting
- N- Spindle Shaft
- O- Deck

Spindles up to Model Year 2009 (MY09) can be differentiated by the side mount lubrication fitting, cast finish sides and four mounting cap screws through the top of the deck.

#### 38, 42C and 42M Mower Decks To MY09

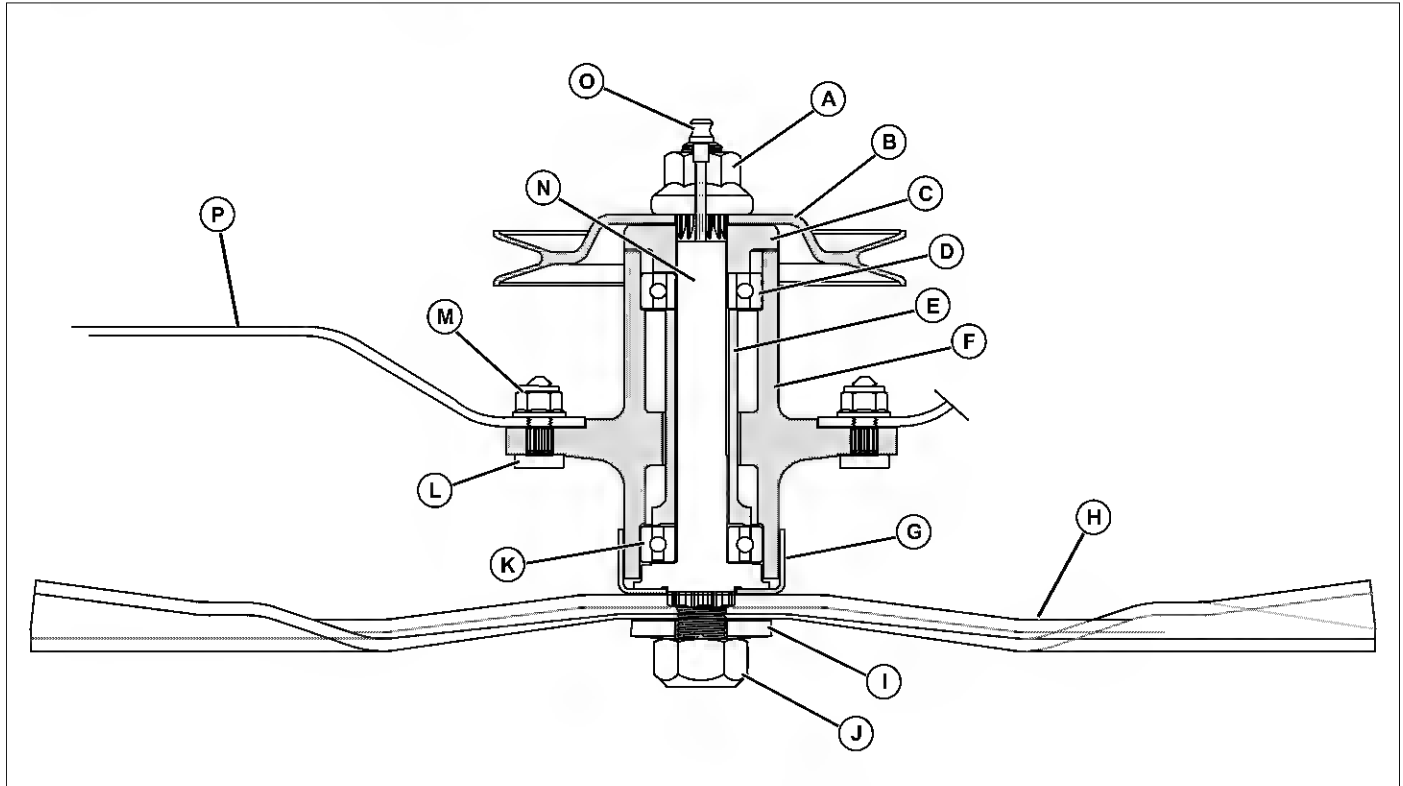
Blade Nut (12mm) Torque ..... 68 N•m (50 lb-ft)

Spindle Sheave Nut ..... 108 N•m (80 lb-ft)

Spindle Mounting Cap Screw ..... 30 N•m (22 lb-ft)

# ATTACHMENTS COMPONENT LOCATION

## Spindles All 38 and 42 Decks MY10-



MIF

- Install lower bearing with steel shield side down and open side of bearing facing up.
- 

### 38, 42C and 42M Mower Decks From MY10

Blade Nut (5/8 in.) Torque ..... 88 N•m (65 lb-ft)

Spindle Sheave Nut ..... 108 N•m (80 lb-ft)

Spindle Mounting Nuts ..... 30 N•m (22 lb-ft)

- A- Spindle Sheave Nut
- B- Spindle Sheave
- C- Upper Seal Ring
- D- Upper Bearing
- E- Spacer
- F- Spindle Housing
- G- Deflector Cup
- H- Blade
- I- Washer
- J- Blade Lock Nut (5/8 in.)
- K- Lower Bearing
- L- Stud (4 used)
- M- Spindle Mounting Nut
- N- Spindle Shaft
- O- Lubrication Fitting
- P- Deck

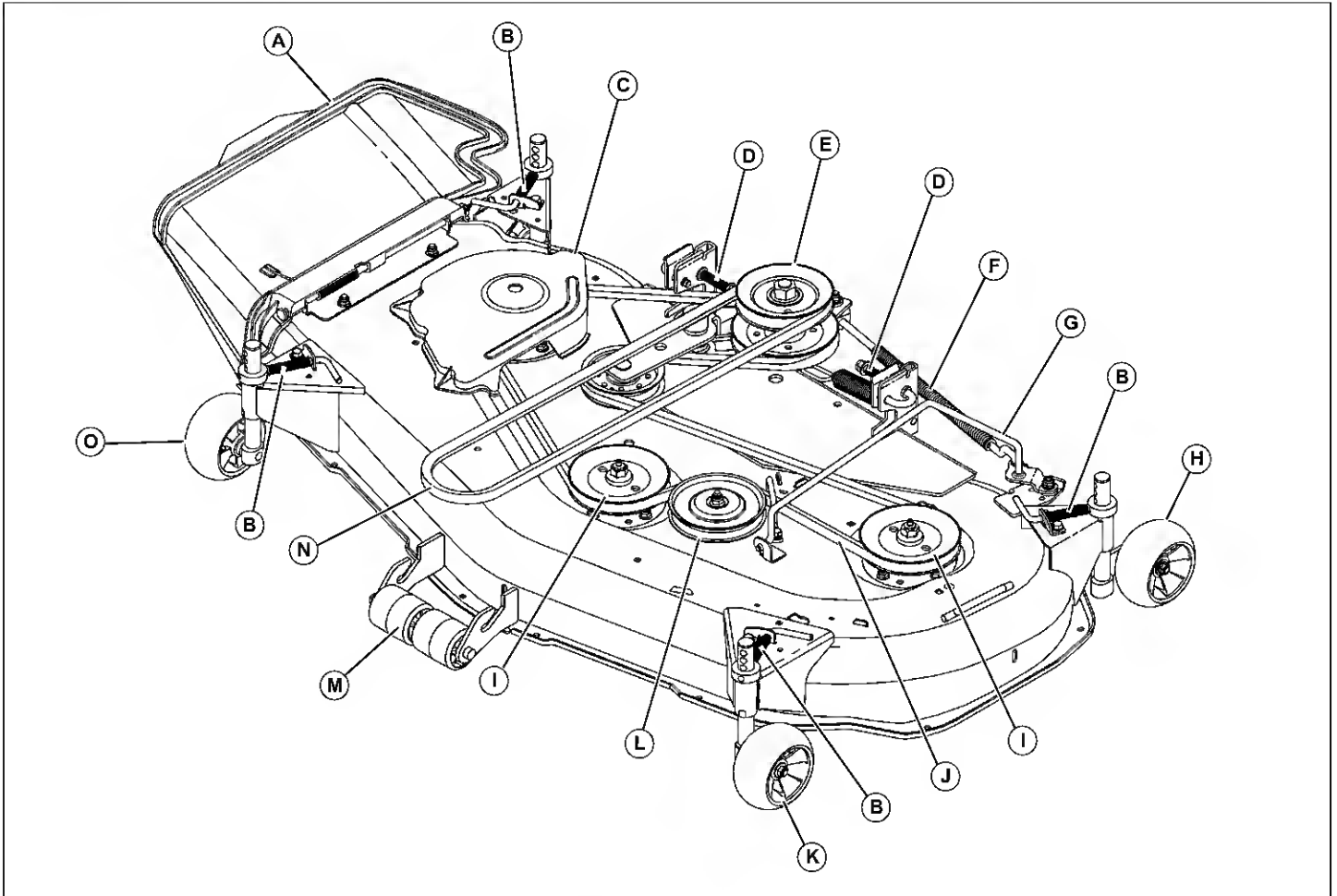
Model Year 2010 (MY10) spindles can be differentiated by the top mount lubrication fitting, smooth sides and mounting studs with nuts on the top of the deck.

### Spindle Assembly:

- Both inner and outer bearing races must be supported during installation.
- Press top bearing against housing shoulder before installation of bottom bearing.

# ATTACHMENTS COMPONENT LOCATION

## 48C Mower Deck



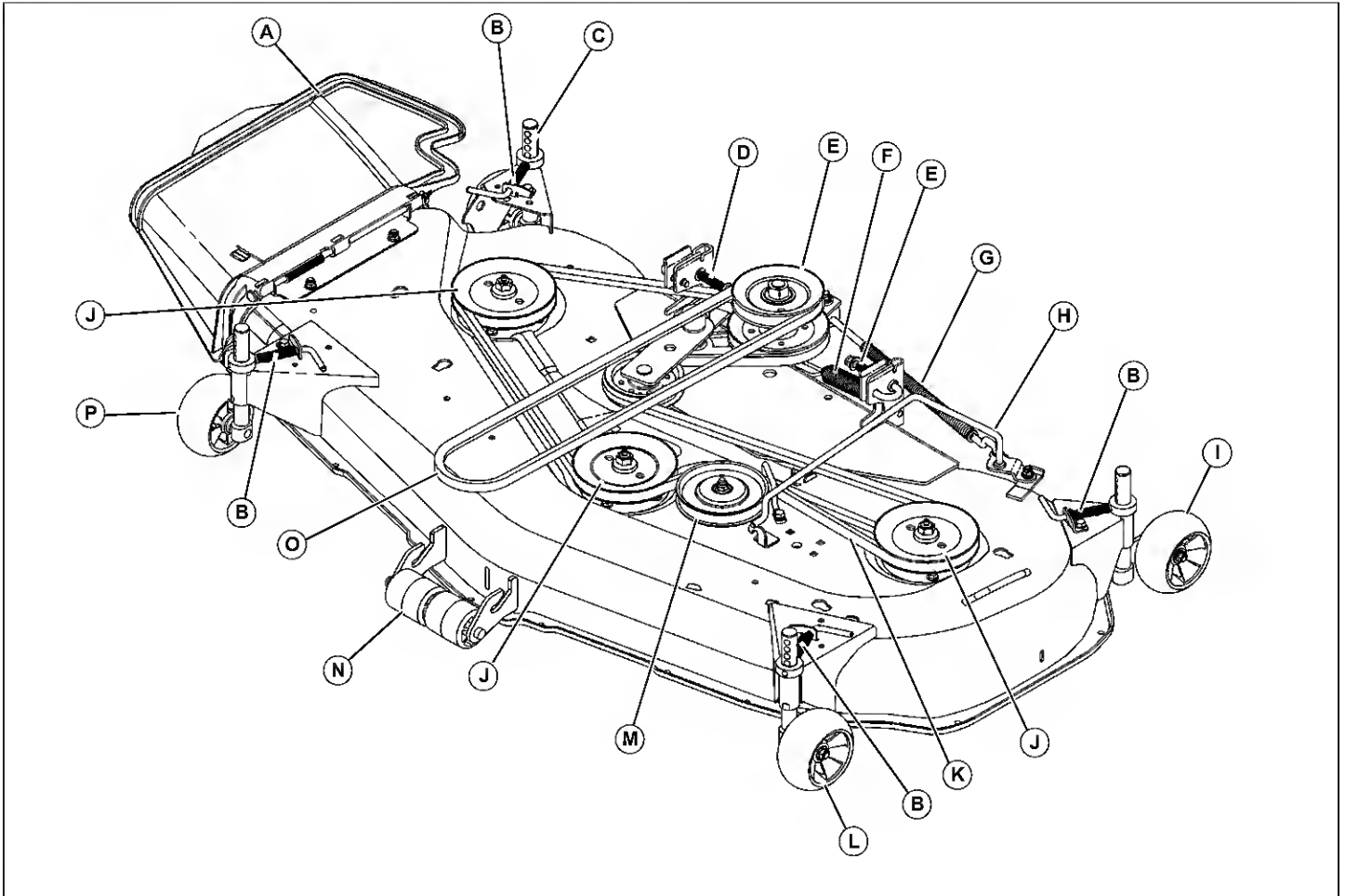
MX37042

### Picture Note: Shown with left belt shield removed

- A- Discharge Chute
- B- Wheel Adjustment Pin Assembly (4 used)
- C- Belt Cover
- D- Deck Mounting "J" Pin (2 used)
- E- Drive Sheave Assembly
- F- Tension Spring Assembly
- G- Tension Handle
- H- Gage Wheel (Left Rear)
- I- Spindle Sheave (3 used)
- J- Secondary Drive Belt
- K- Gage Wheel (Left Front)
- L- Flat Idler Sheave
- M- Rollers
- N- Primary Drive Belt
- O- Gage Wheel (Right Front)

# ATTACHMENTS COMPONENT LOCATION

## 54C Mower Deck



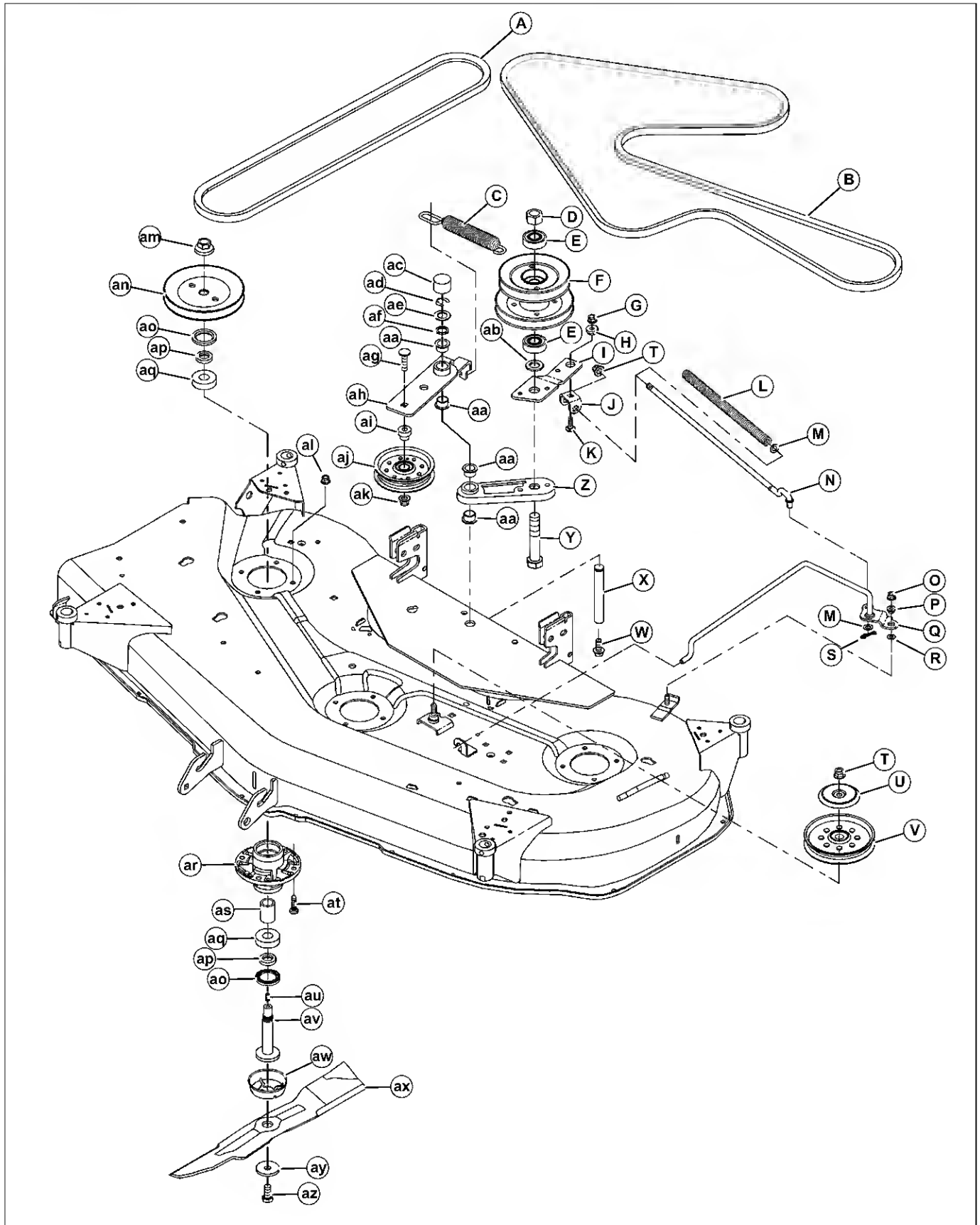
MX37043

**Picture Note: Shown with belt shields removed**

- A- Discharge Chute
- B- Wheel Adjustment Pin Assembly (4 used)
- C- Gage Wheel (Right Rear)
- D- Deck Mounting "J" Pin (2 used)
- E- Drive Sheave Assembly
- F- Idler Spring
- G- Tension Spring Assembly
- H- Tension Handle
- I- Gage Wheel (Left Rear)
- J- Spindle Sheave (3 used)
- K- Secondary Drive Belt
- L- Gage Wheel (Left Front)
- M- Flat Idler Sheave
- N- Rollers
- O- Primary Drive Belt
- P- Gage Wheel (Right Front)

# ATTACHMENTS COMPONENT LOCATION

## Idlers and Sheaves - 48C and 54C Decks



## ATTACHMENTS COMPONENT LOCATION

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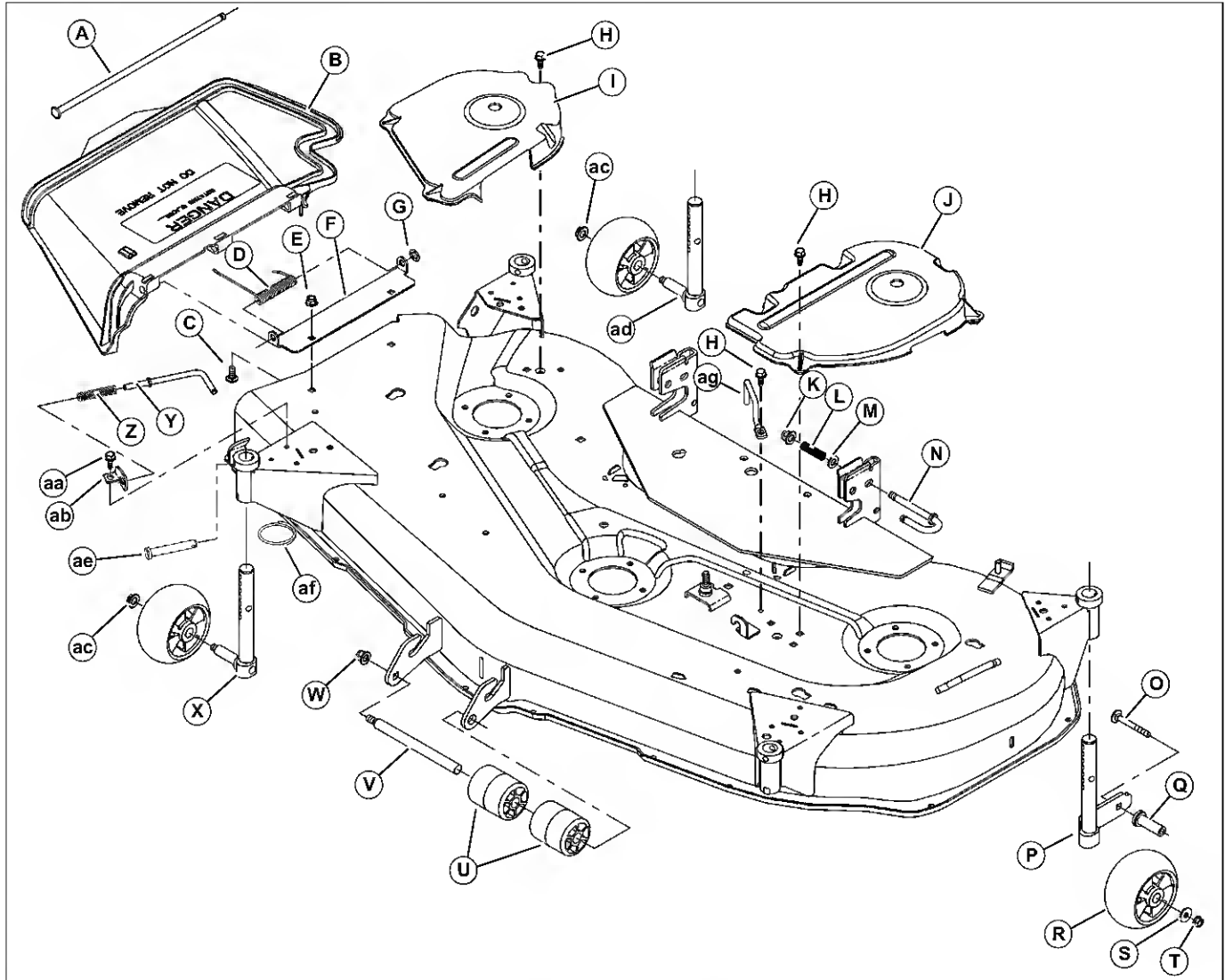
MX37044

A- Primary Drive Belt  
B- Secondary Drive Belt  
C- Idler Extension Spring  
D- Nut 3/4 in.  
E- Ball Bearing (2 used)  
F- Drive Sheave Assembly  
G- Lock Nut (M8)  
H- Bushing  
I- Jacksheave Pivot Bracket  
J- Channel  
K- Bolt (M8 X 25)  
L- Compression Spring  
M- Washer (10.50 X 18 X 1.60 mm)  
N- Tensioner Rod  
O- Lock Nut (M8)  
P- Bushing  
Q- Tensioner Handle  
R- Washer (8.40 X 16 X 1.60 mm)  
S- Spring Locking Pin  
T- Lock Nut (M10, 2 used)  
U- Shield  
V- Idler Sheave  
W- Screw (M10 X 25)  
X- Shaft  
Y- Cap Screw (3/4 X 4 in.)  
Z- Arm  
AA- Bushing (4 used)  
AB- Washer (20 X 34 X 3 mm)  
AC- Cap  
AD- Snap Ring  
AE- Washer (25/32 X 5/16 X 0.60 in.)  
AF- Seal  
AG- Bolt (M10 X 40)  
AH- Secondary Tensioner Arm  
AI- Bushing  
AJ- Sheave Assembly  
AK- Lock Nut (M10)  
AL- Lock Nut (M8, 12 used)  
AM- Locking Nut (3 used)  
AN- Spindle Sheave (3 used)  
AO- Seal (6 used)  
AP- Bushing (6 used)  
AQ- Ball Bearing (6 used)  
AR- Spindle Housing (3 used)  
AS- Spacer  
AT- Screw (12 used)  
AU- Grease Fitting (3 used)

AV- Blade Spindle (3 used)  
AW- Deflector (3 used)  
AX- Blade (3 used)  
AY- Washer (3 used)  
AZ- Cap Screw (M12 X 25, 3 used)

# ATTACHMENTS COMPONENT LOCATION

## Shields - 48C and 54C Decks



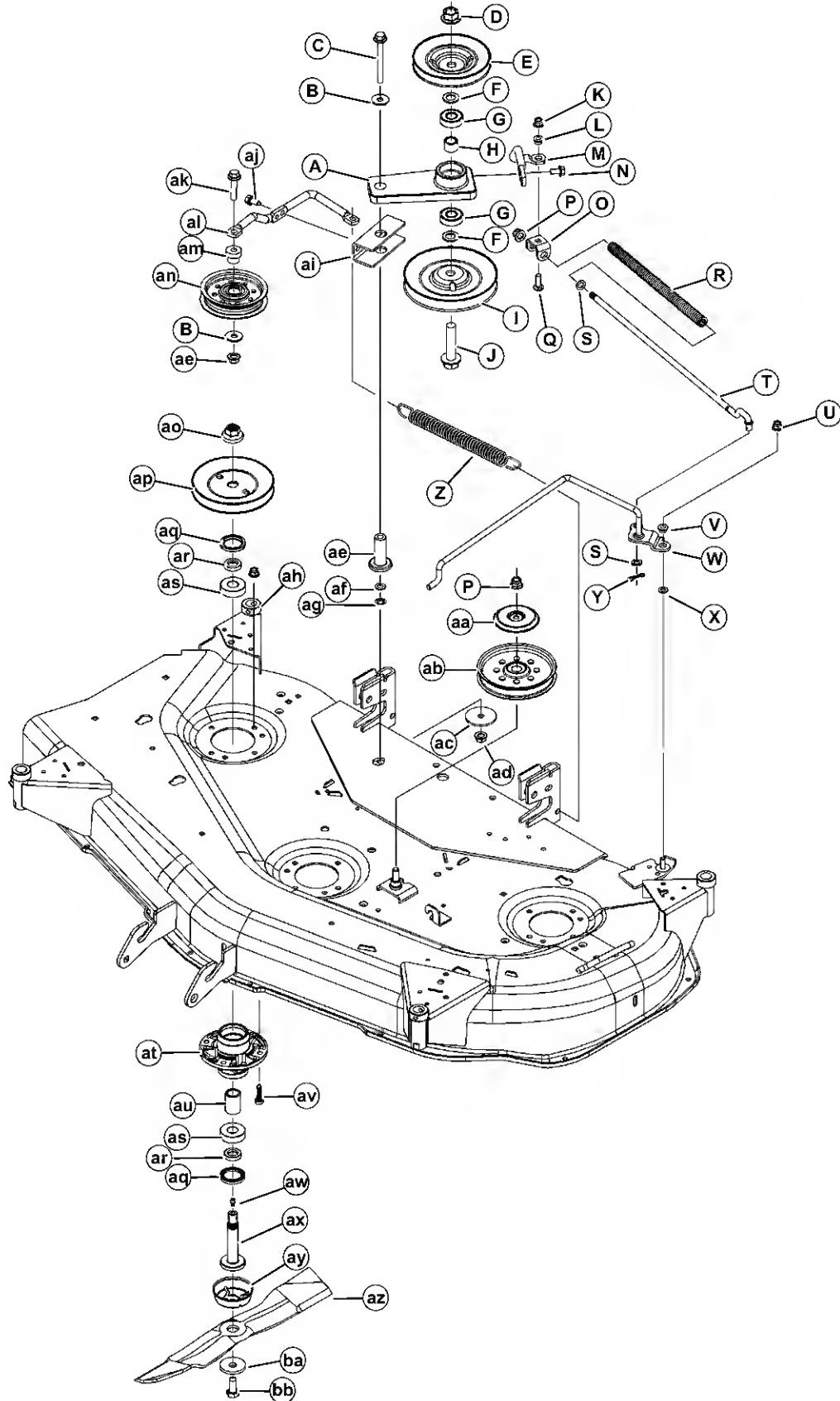
MX37980

- |                                      |   |
|--------------------------------------|---|
| A- Pin                               | Q- Bushing                                      |
| B- Discharge Chute                   | R- Wheel (4 used)                               |
| C- Bolt (2 used)                     | S- Washer (4 used)                              |
| D- Torsion Spring                    | T- Flange Nut                                   |
| E- Lock Nut (M8, 2 used)             | U- Roller (2 used)                              |
| F- Hinge                             | V- Stud   |
| G- Push Nut                          | W- Lock Nut (3 used)                            |
| H- Cap Screw                         | X- Arm  |
| I- RH Belt Cover                     | Y- Pin Fastener (4 used) see AE and AF below    |
| J- LH Belt Cover                     | Z- Extension Spring (4 used)                    |
| K- Lock Nut (M10, 3 used)            | AA- Screw (4 used)                              |
| L- Compression Spring (2 used)       | AB- Bracket (4 used)                            |
| M- Washer (10.5 X 20 X 2 mm, 2 used) | AC- Lock Nut (3 used)                           |
| N- Pin Fastener (2 used)             | AD- Arm (2 used)                                |
| O- Bolt (M8 X 70, 4 used)            | AE- Pin Fastener (4 used) may replace Y to AB   |
| P- Arm                               | AF- Retaining Ring (4 used) may replace Y to AB |
|                                      | AG- Belt Guide                                  |



# ATTACHMENTS COMPONENT LOCATION

## Idlers and Sheaves - 48C Deck (SN 85001-)



## ATTACHMENTS COMPONENT LOCATION

---

MX39835

A- Jacksheave Pivot Arm

B- Washer

C- Bolt

D- Nut 3/4 in.

E- Drive Sheave

F- Washer

G- Ball Bearing (2 used)

H- Spacer

I- Sheave

J- Bolt

K- Lock Nut (M8)

L- Bushing

M- Arm

N- Cap Screw

O- Channel

P- Lock Nut (M10, 2 used)

Q- Bolt (M10)

R- Compression Spring

S- Washer (10.50 X 18 X 1.60 mm, 2 used)

T- Tensioner Rod

U- Lock Nut (M8)

V- Bushing

W- Tensioner Handle

X- Washer (8.40 X 16 X 1.60 mm)

Y- Spring Locking Pin

Z- Idler Extension Spring

AA- Shield

AB- Idler Sheave

AC- Washer

AD- Lock Nut (2 used)

AE- Bushing

AF- Washer

AG- Push Nut

AH- Lock Nut (M8, 12 used)

AI- Bolt

AJ- Channel

AK- Bolt

AL- Secondary Tensioner Arm

AM- Bushing

AN- Sheave Assembly

AO- Locking Nut (3 used)

AP- Spindle Sheave (3 used)

AQ- Seal (6 used)

AR- Bushing (6 used)

AS- Ball Bearing (6 used)

AT- Spindle Housing (3 used)

AU- Spacer

AV- Screw (12 used)

AW- Grease Fitting (3 used)

AX- Blade Spindle (3 used)

AY- Deflector (3 used)

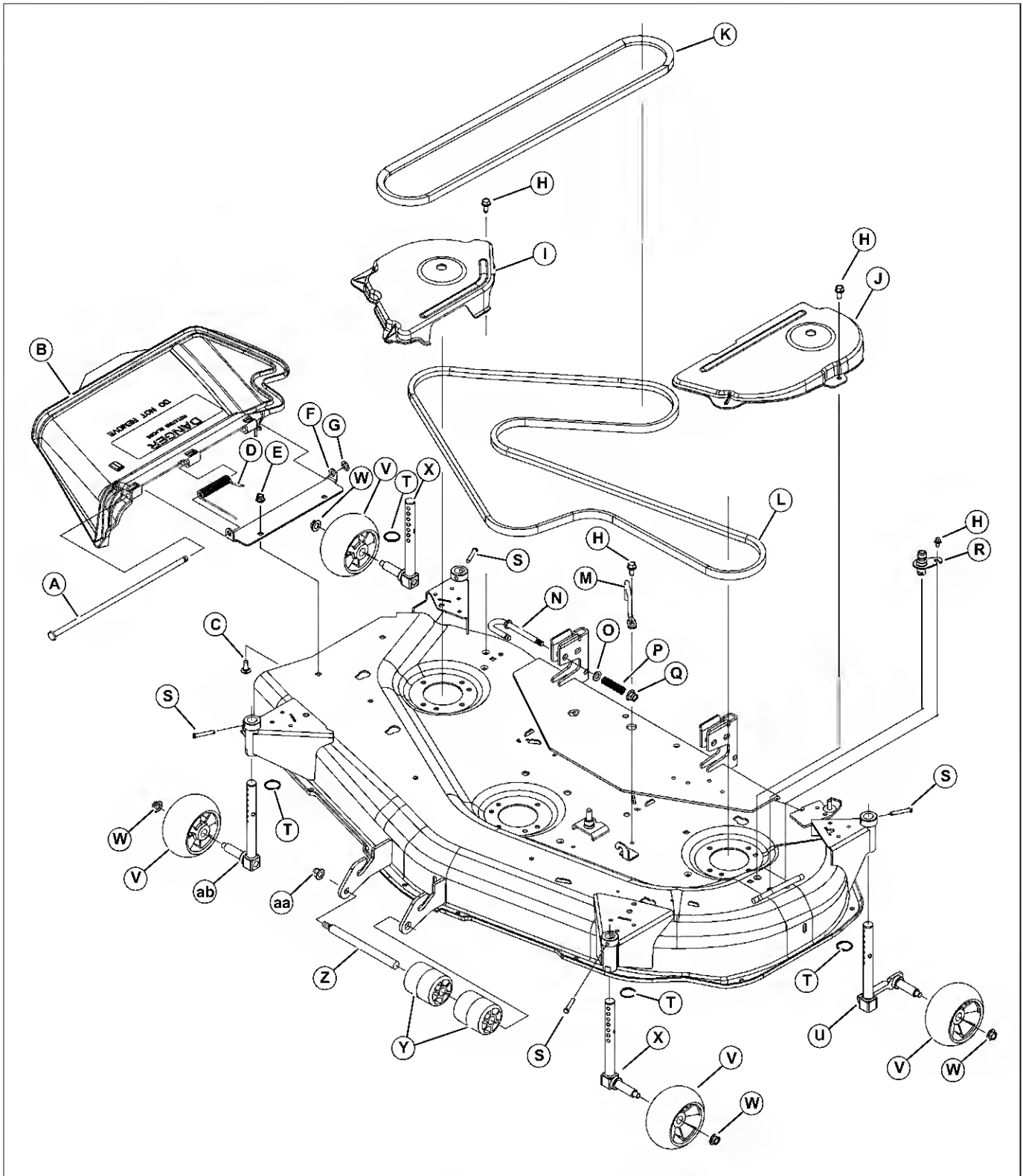
AZ- Blade (3 used)

BA- Washer (3 used)

BB- Cap Screw (M12 X 25, 3 used)

# ATTACHMENTS COMPONENT LOCATION

Shields - 48C Deck (SN 85001-)



MX39836

A- Pin  
B- Discharge Chute  
C- Bolt (2 used)

D- Torsion Spring  
E- Lock Nut (M8, 2 used)  
F- Hinge  
G- Push Nut

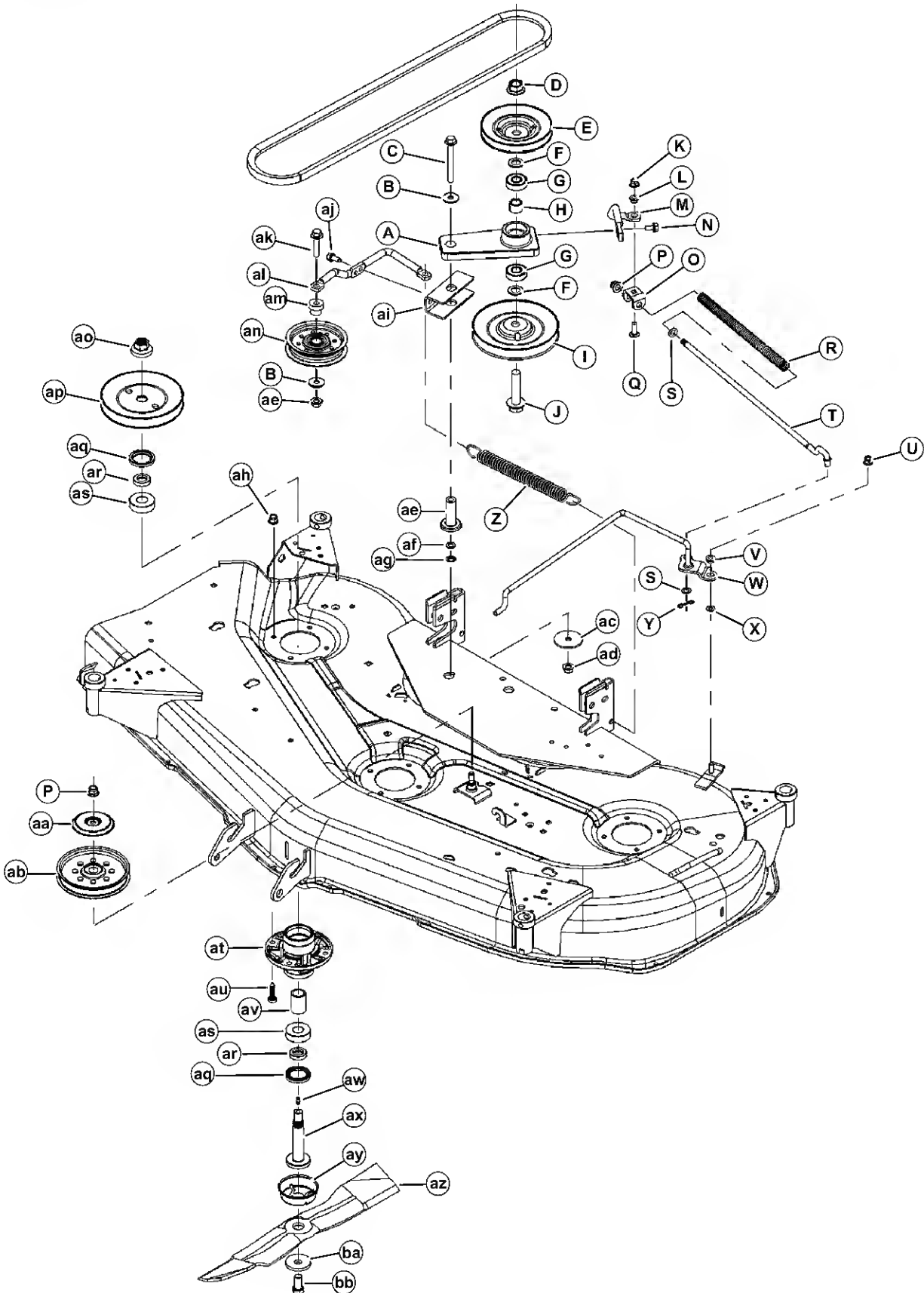
## ATTACHMENTS COMPONENT LOCATION

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H- Screw  
I- RH Belt Cover  
J- LH Belt Cover  
K- Drive Belt  
L- Drive Belt  
M- Belt Guide  
N- Pin Fastener (2 used)  
O- Washer (10.5 X 20 X 2 mm, 2 used)  
P- Compression Spring (2 used)  
Q- Lock Nut (M10, 2 used)  
R- Wash Port  
S- Pin (4 used)  
T- Ring (4 used)  
U- Arm  
V- Wheel (4 used)  
W- Lock Nut (4 used)  
X- Arm (2 used)  
Y- Roller (2 used)  
Z- Stud  
AA- Lock Nut  
AB- Arm

# ATTACHMENTS COMPONENT LOCATION

## Idlers and Sheaves - 54C Deck (SN 85001-)



## ATTACHMENTS COMPONENT LOCATION

MX39828

A- Jacksheave Pivot Arm

B- Washer

C- Bolt

D- Nut 3/4 in.

E- Drive Sheave

F- Washer

G- Ball Bearing (2 used)

H- Spacer

I- Sheave

J- Bolt

K- Lock Nut (M8)

L- Bushing

M- Arm

N- Cap Screw

O- Channel

P- Lock Nut (M10, 2 used)

Q- Bolt (M10)

R- Compression Spring

S- Washer (10.50 X 18 X 1.60 mm, 2 used)

T- Tensioner Rod

U- Lock Nut (M8)

V- Bushing

W- Tensioner Handle

X- Washer (8.40 X 16 X 1.60 mm)

Y- Spring Locking Pin

Z- Idler Extension Spring

AA- Shield

AB- Idler Sheave

AC- Washer

AD- Lock Nut (2 used)

AE- Bushing

AF- Washer

AG- Push Nut

AH- Lock Nut (M8, 12 used)

AI- Bolt

AJ- Channel

AK- Bolt

AL- Secondary Tensioner Arm

AM- Bushing

AN- Sheave Assembly

AO- Locking Nut (3 used)

AP- Spindle Sheave (3 used)

AQ- Seal (6 used)

AR- Bushing (6 used)

AS- Ball Bearing (6 used)

AT- Spindle Housing (3 used)

AU- Spacer

AV- Screw (12 used)

AW- Grease Fitting (3 used)

AX- Blade Spindle (3 used)

AY- Deflector (3 used)

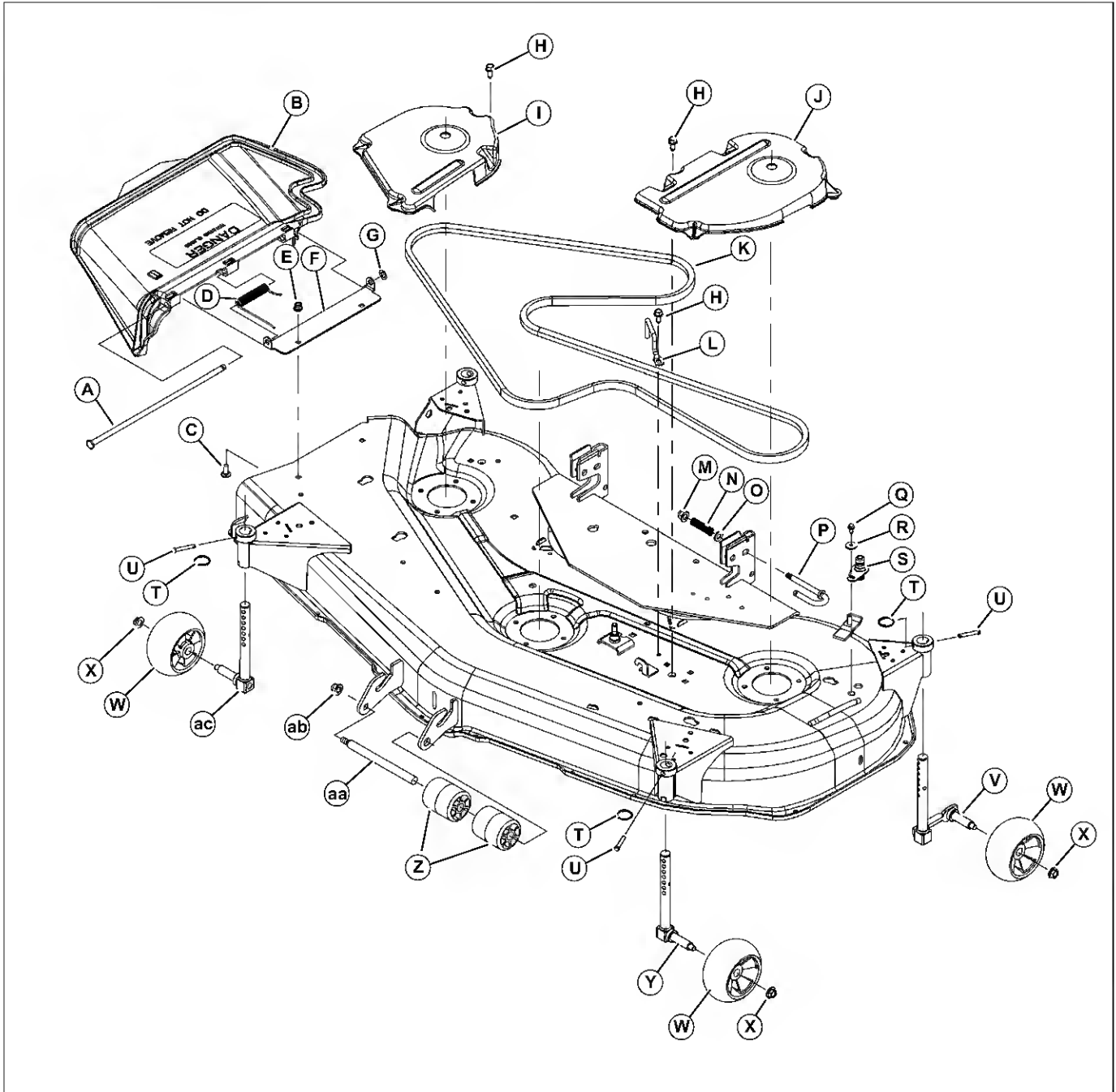
AZ- Blade (3 used)

BA- Washer (3 used)

BB- Cap Screw (M12 X 25, 3 used)

# ATTACHMENTS COMPONENT LOCATION

Shields - 54C Deck (SN 85001-)



MX39829

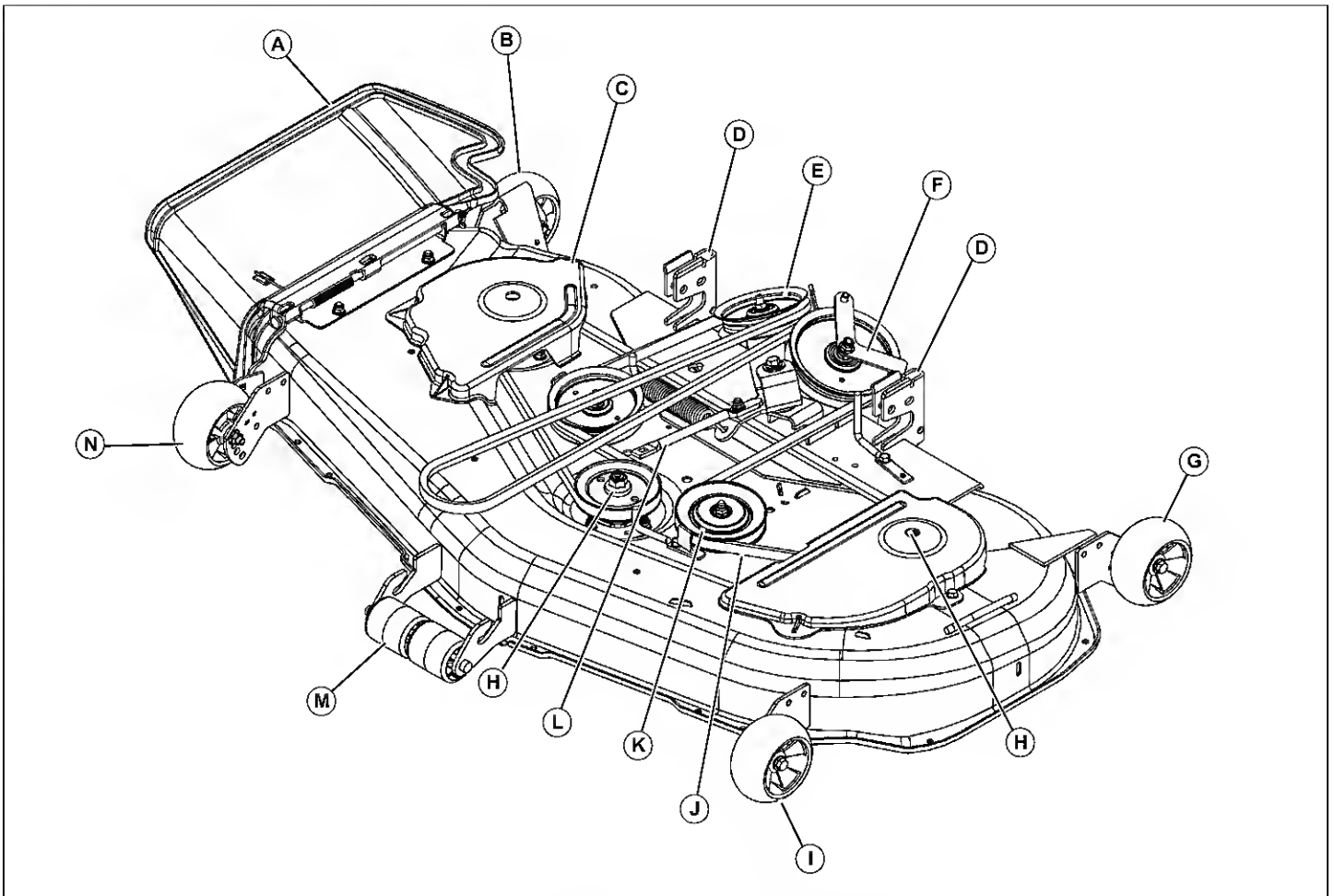
- A- Pin
- B- Discharge Chute
- C- Bolt (2 used)
- D- Torsion Spring
- E- Lock Nut (M8, 2 used)
- F- Hinge
- G- Push Nut
- H- Screw
- I- RH Belt Cover
- J- LH Belt Cover

- K- Drive Belt
- L- Belt Guide
- M- Lock Nut (M10, 2 used)
- N- Compression Spring (2 used)
- O- Washer (10.5 X 20 X 2 mm, 2 used)
- P- Pin Fastener (2 used)
- Q- Bolt
- R- Washer
- S- Wash Port
- T- Ring (4 used)

## ATTACHMENTS COMPONENT LOCATION

U- Pin Fastener (4 used)  
V- Arm  
W- Wheel (4 used)  
X- Flange Nut (4 used)  
Y- Arm (2 used)  
Z- Roller (2 used)  
AA- Stud  
AB- Lock Nut  
AC- Arm

### 48C Single Belt Mower Deck



MX38140

**Picture Note: Shown with left belt shield removed**

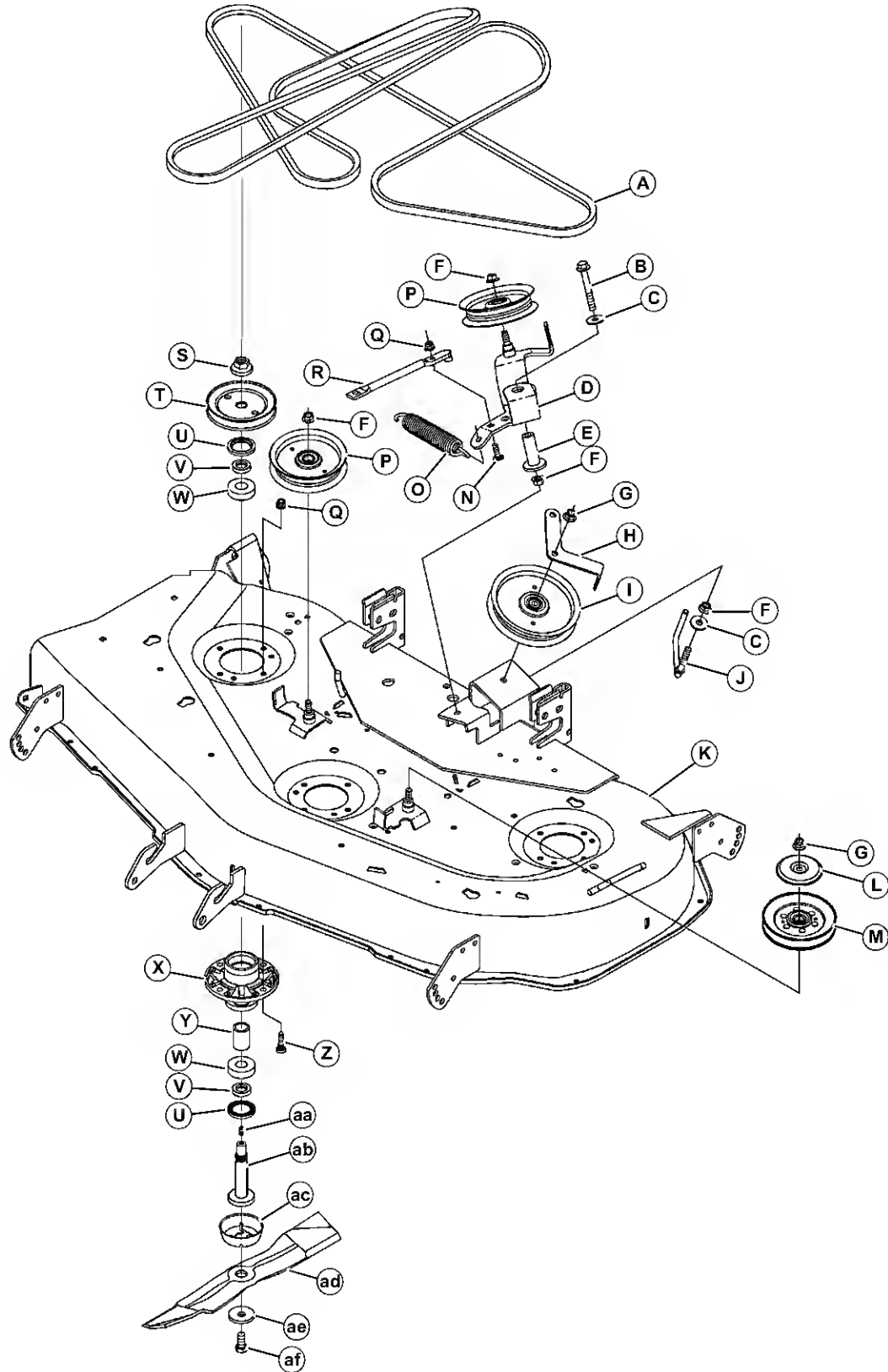
A- Discharge Chute  
B- Gage Wheel (Right Rear)  
C- Belt Cover  
D- Deck Mounting Bracket  
E- Tension Sheave Assembly  
F- Idler Sheave Assembly  
G- Gage Wheel (Left Rear)

H- Spindle Sheave (3 used)  
I- Gage Wheel (Left Front)  
J- Belt  
K- Flat Idler Sheave  
L- Tension Release Arm  
M- Rollers  
N- Gage Wheel (Right Front)



# ATTACHMENTS COMPONENT LOCATION

## Idlers and Sheaves - 48C Single Belt Deck



# ATTACHMENTS COMPONENT LOCATION

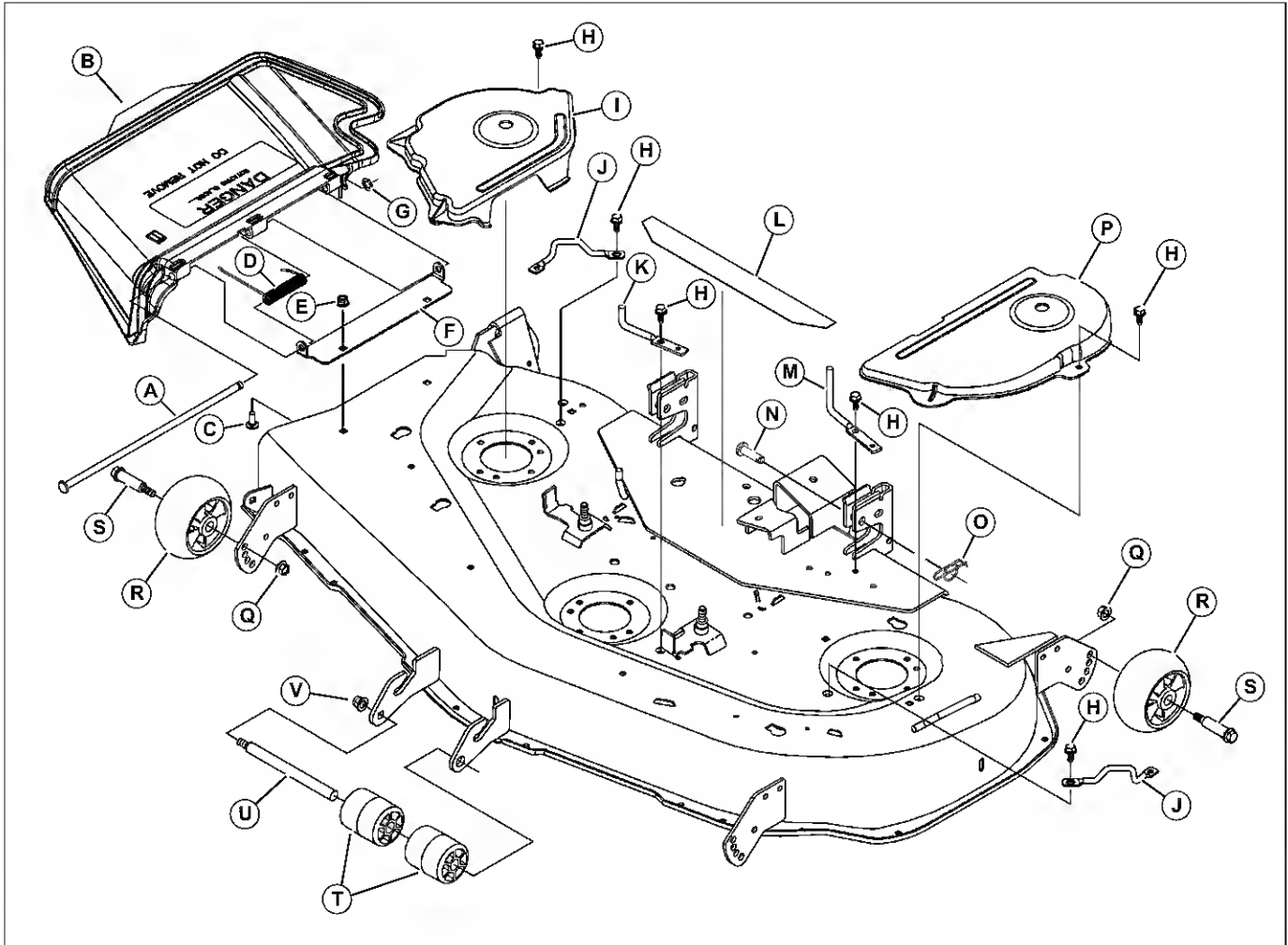
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MX38141

A- Belt  
B- Bolt  
C- Washer (2 used)  
D- Jacksheave Pivot Bracket  
E- Bushing  
F- Flange Nut (4 used)  
G- Flange Nut (2 used)  
H- Belt Guide  
I- Idler Sheave  
J- Belt Guide  
K- Deck Weldment  
L- Shield  
M- Idler Sheave  
N- Carriage Bolt  
O- Idler Extension Spring  
P- Idler Sheave (2 used)  
Q- Lock Nut (2 used)  
R- Tensioner Handle  
S- Locking Nut (3 used)  
T- Spindle Sheave (3 used)  
U- Seal (6 used)  
V- Bushing (6 used)  
W- Ball Bearing (6 used)  
X- Spindle Housing (3 used)  
Y- Spacer  
Z- Screw (12 used)  
AA- Grease Fitting (3 used)  
AB- Blade Spindle (3 used)  
AC- Deflector (3 used)  
AD- Blade (3 used)  
AE- Washer (3 used)  
AF- Cap Screw (3 used)

# ATTACHMENTS COMPONENT LOCATION

## Shields - 48C Single Belt Deck



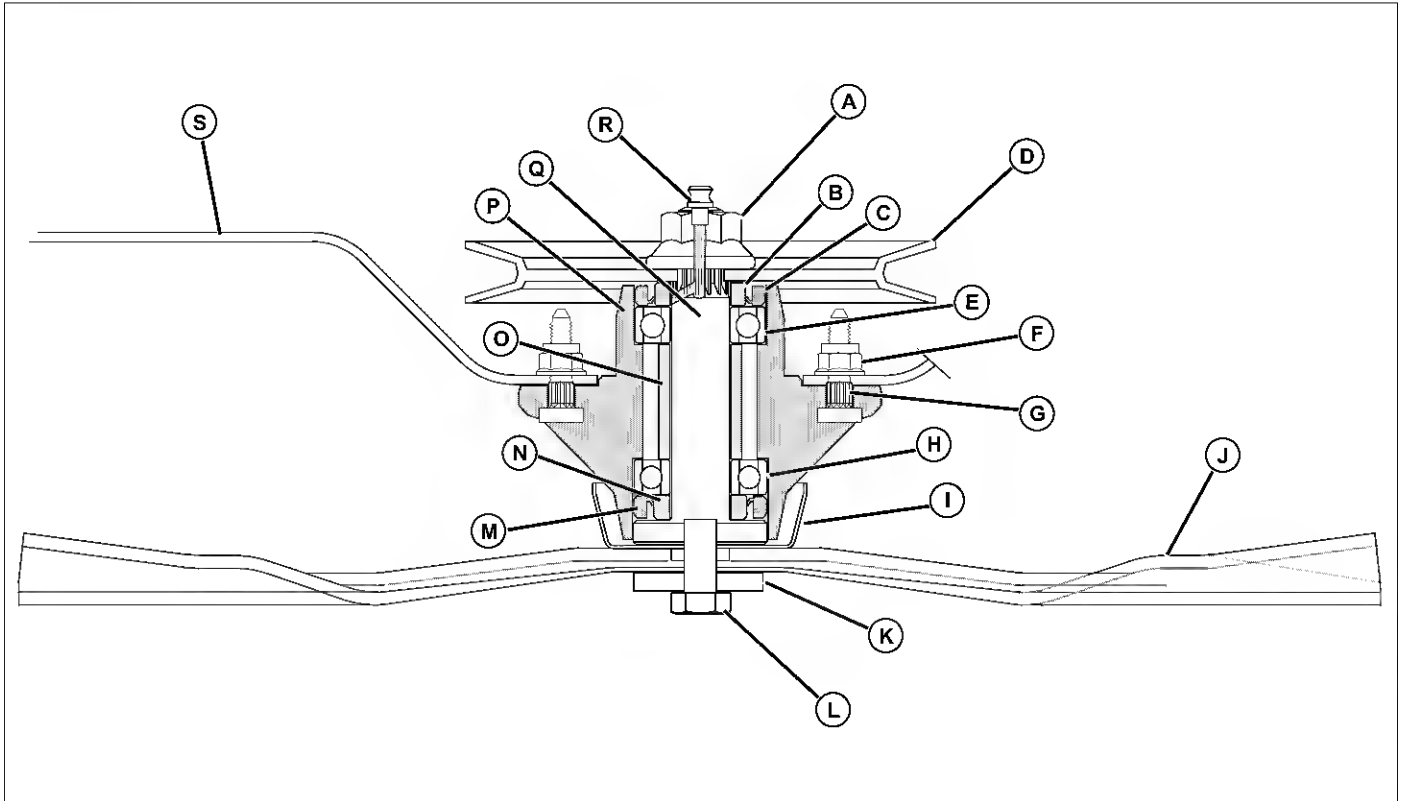
MX38142

- A- Pin
- B- Discharge Chute
- C- Bolt (2 used)
- D- Torsion Spring
- E- Lock Nut (M8, 2 used)
- F- Hinge
- G- Push Nut
- H- Cap Screw
- I- RH Belt Cover
- J- Belt Guide (2 used)
- K- Belt Guide
- L- Wear Plate, Plastic
- M- Belt Guide
- N- Pin (2 used)
- O- Clip (2 used)
- P- LH Belt Cover
- Q- Flange Nut
- R- Wheel
- S- Shoulder Bolt

- T- Roller (2 used)
- U- Stud
- V- Flange Nut

# ATTACHMENTS COMPONENT LOCATION

## Spindle Section - 48C and 54C Decks



MIF

- A- Nut
- B- Upper Bushing
- C- Upper Seal
- D- Spindle Sheave
- E- Upper Bearing
- F- Lock Nut M8 (4 used)
- G- Screw (4 used)
- H- Lower Bearing
- I- Deflector Cup
- J- Blade
- K- Washer
- L- Cap Screw M12x25
- M- Lower Seal
- N- Lower Bushing
- O- Spacer
- P- Spindle Housing
- Q- Spindle Shaft
- R- Lubrication Fitting
- S- Deck

# ATTACHMENTS DIAGNOSTICS

## Diagnostics

### Mower Drive Checks

#### Test Conditions

- Machine parked on level surface
- PTO disengaged
- Parking brake locked
- Key switch in Off position

### Attachment Systems Checks

#### PTO Clutch and Drive Sheave

1. Is PTO clutch and drive sheave tight on crankshaft?  
(Key not damaged or missing?)

Yes: Go to next step.

No: Tighten cap screw. Replace key if necessary.

2. Is air gap properly adjusted?

Yes: Go to next step.

No: Repair and adjust as needed.

3. Is belt on sheave?

Yes: Go to next step.

No: Install belt.

4. Is sheave binding, damaged or worn?

Yes: Replace sheave.

No: Go to next step.

5. Does sheave angle match belt angle?

Yes: Go to next check.

No: Check jack sheave and PTO sheave. Repair or replace components as necessary.

#### Primary Drive Belt: 48 and 54 Inch Decks

1. Is primary drive belt damaged, worn, broken or turned over?

Yes: Replace primary drive belt. See "Replacing Mower Drive Belt (Primary) (48 in. and 54 in. Mowers)" on page 544.

No: Go to next check.

#### Jack Sheave

1. Is sheave binding, damaged or worn?

Yes: Replace sheave.

No: Go to next step.

2. Does sheave angle match belt angle?

Yes: Go to next step.

No: Check jack sheave and PTO sheave. Repair or replace components as necessary.

3. Is jack sheave arm binding, damaged, or worn?

Yes: Replace arm.

No: Go to next step.

4. Is nut at correct torque?

Yes: Go to next check.

No: Tighten nut to specification.

#### Primary Belt Tension Spring and Rod

1. Is belt tensioning handle in tension position?

Yes: Go to next step.

No: Move to tension position.

2. Is primary belt tension spring or rod damaged, worn or weak?

Yes: Repair or replace components as necessary.

No: Go to next check.

#### Secondary Drive Belt

1. Is secondary drive belt damaged, worn, broken or turned over?

Yes: Replace belt.

No: Go to next check.

#### Secondary Drive Belt Tensioning Spring

1. Is secondary drive belt tensioning spring damaged, worn or weak?

Yes: Replace spring.

No: Go to next check.

#### Secondary Drive Belt Idler and Pivot Arm

1. Is secondary drive belt idler and pivot arm binding, damaged or worn?

Yes: Repair or replace components as necessary.

No: Go to next step.

2. Is pivot arm bent, keeping idler from being parallel to belt?

Yes: Repair or replace components as necessary.

No: Go to next check.

#### Fixed Idler

1. Is idler binding, damaged or worn?

Yes: Repair or replace components as necessary.

No: Go to next check.

#### Spindle Sheaves

1. Is spindle sheave tight on spindle with key in place?

# ATTACHMENTS    DIAGNOSTICS

---

Yes: Go to next step.

No: Tighten nut and install key as needed.

2. Is spindle sheave damaged, bent or not running straight?

Yes: Repair or replace components as necessary.

No: Go to next step.

3. Does sheave angle matches belt angle?

Yes: Repair or replace components as necessary.

No: Go to next check.

## Spindle and Housing

1. Have bearings failed?

Yes: Replace bearings. See "Spindle - 38 and 42-Inch Decks" on page 546, or "Spindle - 48 and 54-Inch Decks" on page 547.

No: Go to next check.

## Mower Deck Lift Linkage

1. Is mower deck lift linkage mounting hardware tight and in good condition?

Yes: Go to next check.

No: Tighten or replace as needed.

## Engine

1. Check engine adjustments and condition. Is engine is running at correct rpm?

No: Adjust engine fast idle and governor.

No: Inform operator that engine should be running at fast idle when mowing.

## Mower Deck Troubleshooting

### Diagnostic Checks:

#### Mower Blade Does Not Rotate

1. Is the PTO clutch engaged?

No: Engage PTO. If the PTO will not engage, refer to PTO clutch diagnostics in the Electrical section.

Yes: Go to next step.

2. Is the primary drive belt broken, worn, frayed, glazed, or stretched?

Yes: Replace belt. See appropriate belt replacement section.

No: Go to next step.

3. Is the primary belt quick release belt tensioning handle locked in place?

Yes: Lock handle in place.

No: Go to next step.

4. Is the secondary drive belt tensioning spring weak or unhooked.

Yes: Replace or reattach spring.

#### Mower Deck Vibrates

1. Are blades out of balance?

Yes: Balance blades. See "Sharpen and Balance Blades" on page 540.

No: Go to next step.

2. Are blades bent?

Yes: Replace blades. See "Mower Blade Removal and Installation" on page 539.

No: Go to next step.

3. Are drive sheaves damaged?

Yes: Replace drive sheave(s).

#### Mower Deck Cuts Unevenly or with Striping

1. Are blades dull?

Yes: Sharpen blades. See "Sharpen and Balance Blades" on page 540.

No: Go to next step.

2. Is the deck level side-to-side and front-to-back? See "Checking and Adjusting Mower Level" on page 519.

Yes: Go to next step.

No: Level mower deck side-to-side and/or front-to-back.

3. Are gage wheels adjusted properly?

Yes: Go to next step.

No: Adjust gage wheels. See "Adjusting Mower Deck Wheels" on page 522.

4. Are blades bent?

Yes: Replace blades. See "Mower Blade Removal and Installation" on page 539.

No: Go to next step.

5. Are drive sheaves damaged?

Yes: Replace drive sheave(s).

#### Mower Belt Slips or Jumps Off Sheaves

1. Is the primary drive belt broken, worn, frayed, glazed, or stretched?

Yes: Replace belt. See appropriate belt replacement section.

No: Go to next step.

2. Is the secondary drive belt broken, worn, frayed, glazed, or stretched?

Yes: Replace belt.

# ATTACHMENTS TESTS AND ADJUSTMENTS

No: Go to next step.

3. Is the primary belt quick release belt tensioning handle locked in place?

Yes: Go to next step.

No: Lock handle in place.

4. Is the secondary drive belt tensioning spring weak or unhooked.

Yes: Replace or reattach spring.

No: Go to next step.

5. Are drive sheaves damaged?

Yes: Replace drive sheave(s).

## Mower Deck Drops While Mowing

1. Are the mower deck gauge wheels riding on ground?

Yes: Raise height of gauge wheels

No: Go to next step.

2. Is the lift assist spring set too tight?

Yes: Adjust the lift assist spring so there is very little or no lift effort on the deck from the spring.

No: Go to next step.

3. Is the lift depth stop cam worn or damaged?

Yes: Replace depth stop cam.

No: Go to next step.

4. Is the arm on the depth stop pivot shaft bent?

Yes: Replace shaft.

No: Modify cam to create more positive detent in the landing area where the depth stop pivot shaft cam contacts the cam.

## Tests and Adjustments

### Checking and Adjusting Mower Level



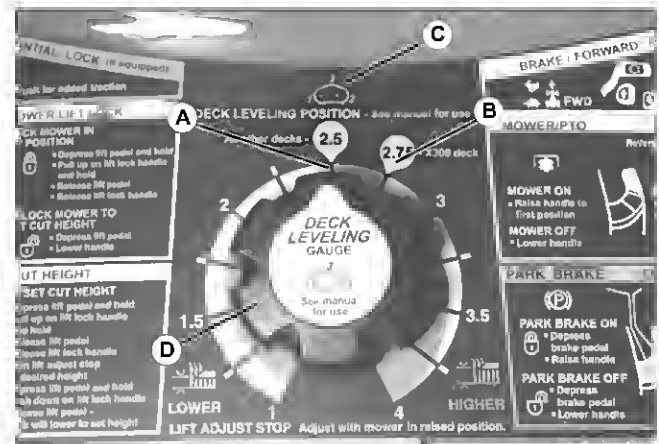
**Caution: Avoid Injury! Rotating blades are dangerous. Before adjusting or servicing mower:**

- Disconnect spark plug wire(s) or battery negative (-) cable to prevent engine from starting accidentally.
- Always wear gloves when handling mower blades or working near blades.

**Note:** Mower wheels should not contact the ground when leveling the deck.

#### Method One

1. Park machine safely on a level surface. See "Parking Safely" in the Safety section.
2. Inflate tires to the correct pressure.



3. The label for the cutting height knob is located on the console of the machine. This label shows deck leveling positions (A & B) and location of deck leveling adjustment points (C). The location of adjustment points will vary slightly between decks:

- Adjustment point 1 is located on the left rear deck rim.
- Adjustment point 2 is located on the right rear deck rim.
- Adjustment point 3 is located on the front deck hanger bracket.

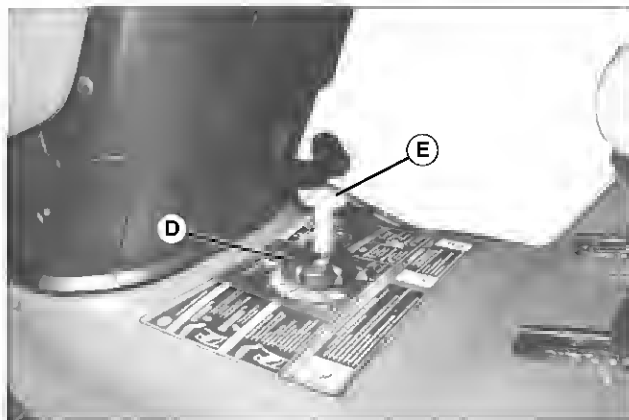
4. Set mower cutting height knob (D) to the deck leveling position for your specific mower deck, and lower deck against stop:

- For X300 models, use position 2.75 (B).

# ATTACHMENTS TESTS AND ADJUSTMENTS

- For X304, X320, X324 and X340 models, use position 2.5 (A).

5. Adjust mower deck gage wheels as necessary so they do not contact the ground surface.

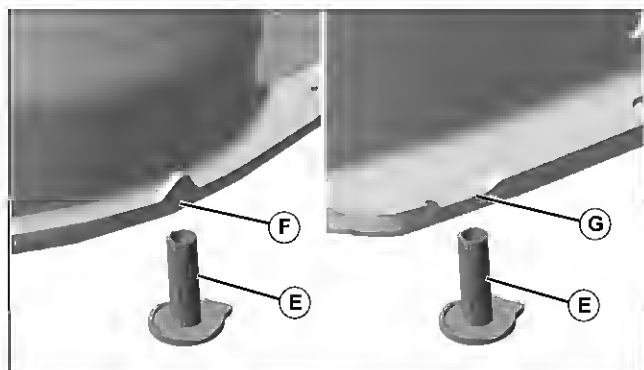


MX36309

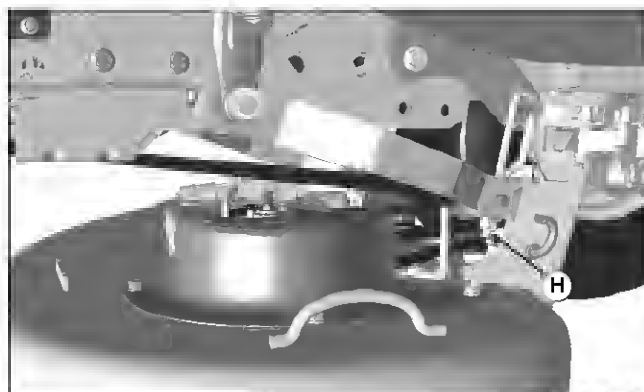
6. Remove the mower deck level gage (E) stored in the mower cutting height knob (D).

7. Adjust mower deck side-to-side level:

**Note:** Adjustment points 1 and 2 on 38, 42 mulching, 48 and 54 mowers have a raised marker (F) for side-to-side measurement; 42 mowers have a recessed area (G).



MX22016a, MX22015, MX36291



MX35843

a. Use gage (E) to measure the height between the

floor and lower deck rim at adjustment point 1 on left rear deck rim. Adjust the left rear adjustment nut (H) until the gage just slips under the deck rim at adjustment point 1.

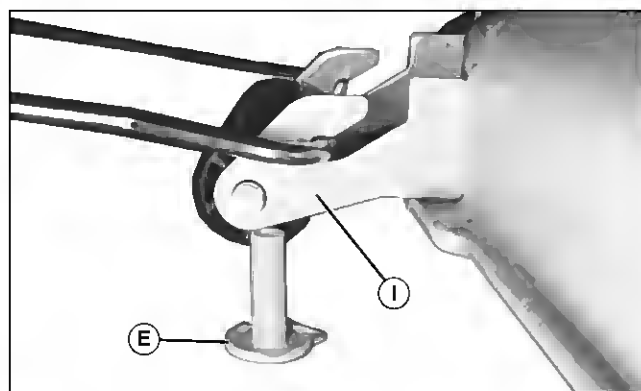
b. Use gage (E) to measure the height between the floor and lower deck rim at adjustment point 2 on right rear deck rim. Adjust the right rear adjustment nut until the gage just slips under the deck rim at adjustment point 2.

**Note:** If an adjustment of more than 1/8 in. is required, adjust both points alternately. A large adjustment on one side can move the other side in the opposite direction.

c. Repeat step a and b, as necessary.

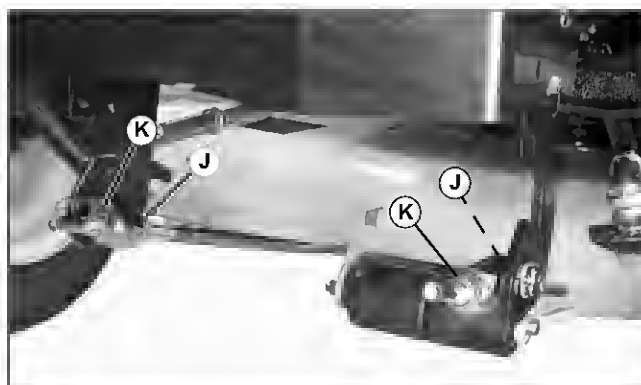
8. Adjust mower deck front-to-back level:

**Note:** Adjustment point 3 has a stamped "3" on side of front deck hanger bracket (I).



MX36292

a. Use gage (E) to measure the height between the floor and front deck hanger bracket at adjustment point 3.



MX36204

b. Adjust mower level, if necessary, by loosening rear nut (J) equally on each side of front lift rod. Turn front nut (K) equally on each side clockwise to raise front of mower or counterclockwise to lower it until gage just slips under adjustment point 3. Tighten rear nuts after



# ATTACHMENTS TESTS AND ADJUSTMENTS

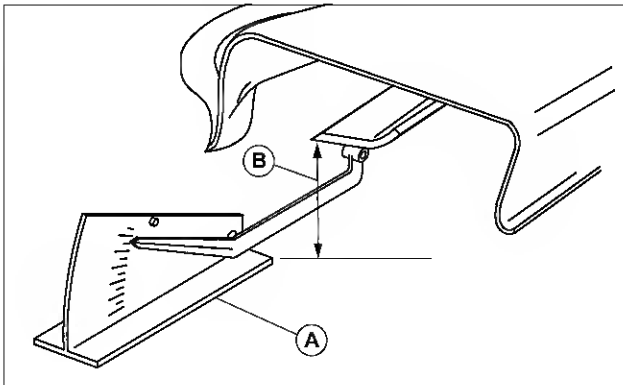
adjustment is complete.

**Note:** Before storing gage, verify that deck will latch in transport position. If it does not latch, turn both rear adjusting nuts counter-clockwise equally to lower rear of deck until deck latch will engage. Check front draft arm adjustment, adjust if necessary.

9. Return the gage to its storage position.

## Method Two

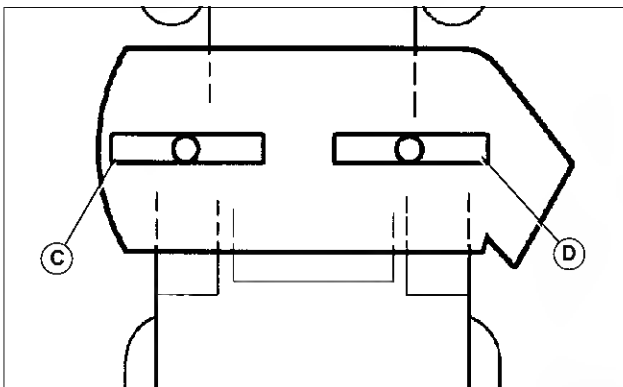
1. Park machine safely. See "Parking Safely" in the Safety section.
2. Inflate tires to the correct pressure.
3. Set mower cutting height knob to preferred cutting height, and lower deck into the mowing position.
4. Measure mower level (side-to-side).



MIF

**Picture Note:** A convenient leveling gauge (A) (AM130907) is available from your dealer.

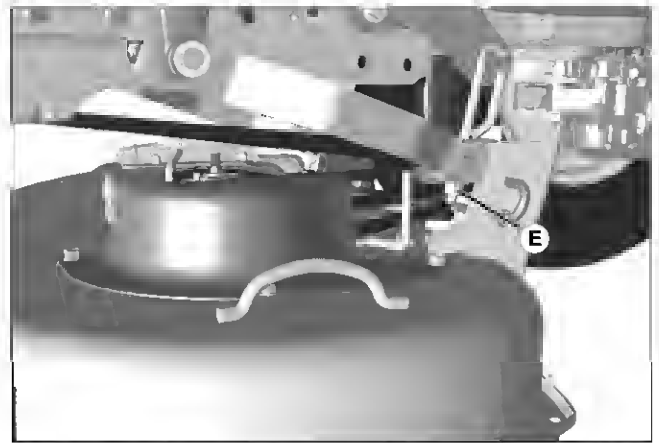
- a. Position mower blades as follows and measure from each outside blade tip (B) to the level surface.



MX4896

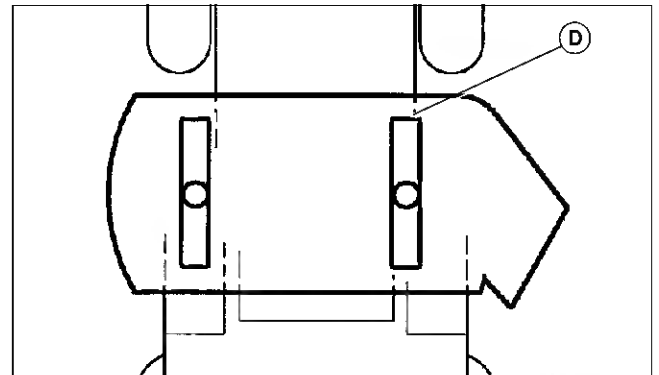
- b. Turn left blade (C) as shown. Hold drive belt and turn right blade (D) as shown. Take measurement for both blades.

The difference between blade measurements must not be more than 3 mm (1/8 in.).



MX35843

- c. Adjust mower level, if necessary, by turning nuts (E) clockwise to raise the side of the mower deck, or counterclockwise to lower the mower deck.
5. Measure mower level (front-to-rear).

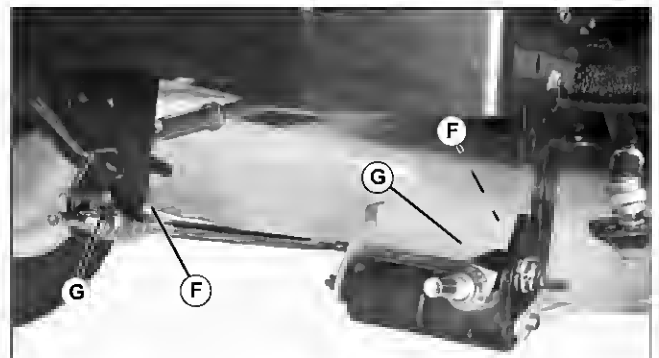


MX4896a

- a. Turn right blade (D) so blade tip points straight forward.
- b. Measure from blade tip to the surface. Take measurement for both blades.

38 and 42 Mowers - The front blade tip must be 3 mm (1/8 in.) lower than rear blade tip.

48 and 54 Mowers - The front blade tip must be 3 - 6 mm (1/8 - 1/4 in.) lower than rear blade tip



MX36204

# ATTACHMENTS TESTS AND ADJUSTMENTS

c. Adjust mower level, if necessary, by loosening rear nut (F) equally on each side of front lift rod. Turn front nut (G) equally on each side clockwise to raise front of mower or counterclockwise to lower it. Tighten rear nuts after adjustment is complete.

**Note:** Verify that deck will latch in transport position. If it does not latch, turn both rear adjusting nuts counterclockwise equally to lower rear of deck until deck latch will engage. Check front lift rod adjustment, adjust if necessary.

## Adjusting Mower Deck Wheels

### Procedure:



**Caution: Avoid Injury! Rotating blades are dangerous. Before adjusting or servicing mower:**

- Disconnect spark plug wire(s) or battery negative (-) cable to prevent engine from starting accidentally.
- Always wear gloves when handling mower blades or working near blades.

**Important: Avoid Damage! The mower deck can be damaged if mower wheels are adjusted wrong:**

- Wheels must not ride on ground supporting mower weight.
- Check wheel adjustment each time cutting height is changed.

1. Park machine safely on a level surface. See "Parking Safely" in the Safety section.

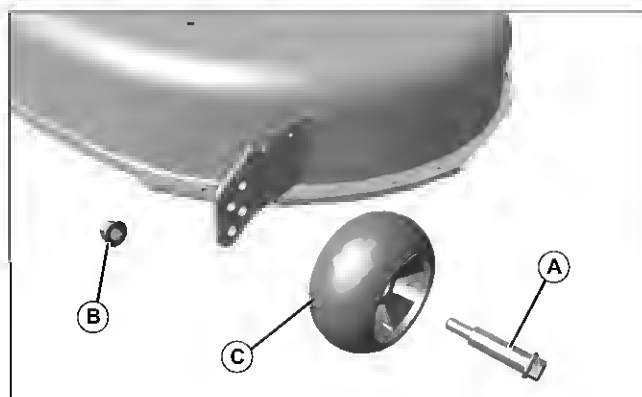
1. Inflate tires to correct pressure.

2. Lower mower deck to the desired mowing position.

3. Measure distance between mower wheels and ground surface:

- 38 Mower - All wheels should be 3-13 mm (1/8-1/2 in.) from ground.
- 42 Mulching Mower - All wheels should be 3-13 mm (1/8-1/2 in.) from ground.
- 42 Mower- All wheels should be 3-9 mm (1/8-3/8 in.) from ground.
- 48 and 54 Mowers - All wheels should be 6-13 mm (1/4-1/2 in.) from ground.

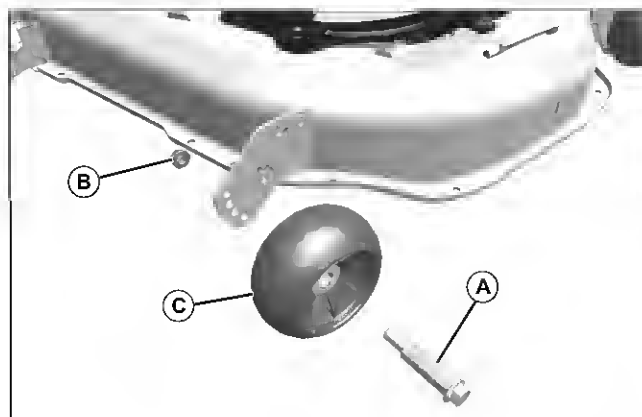
4. Adjust mower wheels to correct height:



MX36202

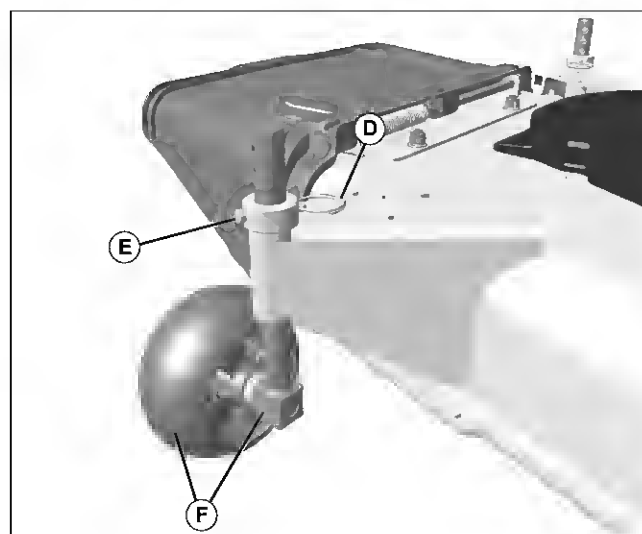
**Picture Note:** 38 mower shown.

- 38 and 42 Mowers - Remove shoulder bolt (A) and nut (B). Move wheel (C) to proper hole position. Secure with shoulder bolt and nut. Tighten nut to 34 N•m (25 lb-ft).



MX37998

- 48 Single Belt Drive Mower - Remove shoulder bolt (A) and nut (B). Move wheel (C) to proper hole position. Secure with shoulder bolt and nut. Tighten nut to 34 N•m (25 lb-ft).



MX37948

# ATTACHMENTS REPAIR

**Picture Note: 48 mower shown.**

- 48 and 54 Two Belt Drive Mowers - Remove locking clip (D), pull pin (E) outward, and move wheel and shaft (F) to proper hole position. Install pin and locking clip to lock wheel in position.

## Repair

### Removing Mower (38 in.) SN -020000

1. Park machine safely. See "Parking Safely" in Safety section.
2. Allow engine and muffler to cool completely.



**Caution: Avoid Injury! Rotating blades are dangerous. Before adjusting or servicing mower:**

- Disconnect spark plug wire(s) or battery negative (-) cable to prevent engine from starting accidentally.
- Always wear gloves when handling mower blades or working near blades.

3. Adjust mower cutting height to lowest position.



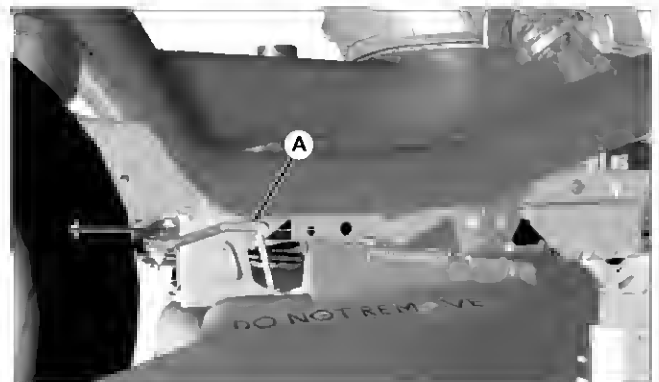
**Caution: Avoid Injury! Lift pedal is spring-assisted and may have unexpected movement. Lock lift pedal when installing or removing mower deck.**

**Note: Because a lift assist is installed on your machine, you may need to lower deck and then pull lift pedal back by hand to lock the lift lever.**

4. Lower mower deck, pull back lift pedal by hand, and pull lift pedal lever to lock.



**Caution: Avoid Injury! Belt tension rod is spring-assisted and under tension. Keep a secure grasp on rod at all times while releasing or applying drive belt tension.**



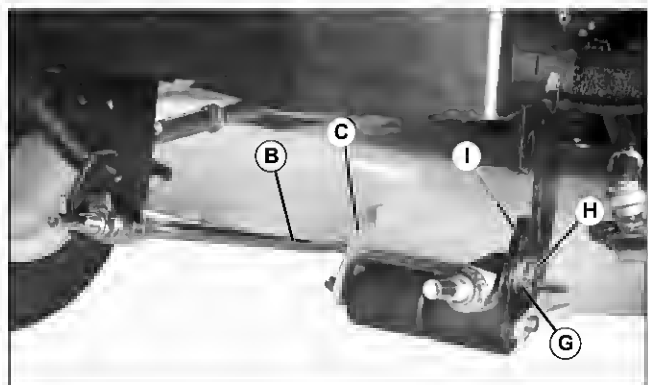
MX36283

**Picture Note: This deck used on machines through SN -040000)**

5. Grasp tension rod (A), under footdeck, securely. Push

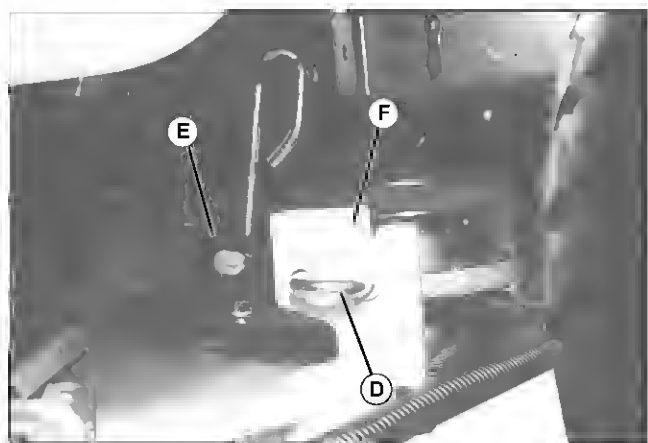
## ATTACHMENTS REPAIR

and hold tension rod rearward, while removing mower belt from engine sheave.



MX36204

6. Remove front draft rod (B) from machine bracket (C).



MX36288

7. Pull and rotate J-pin (D) to release and move rear draft arm (E) away from deck bracket (F). Raise deck slightly via handle to remove pressure on pin when pulling out. Repeat on other side.

8. When operating the machine without the mower deck:

- Remove locking clip (G) from stud (H) on each side, and remove front draft rod from draft bracket (I). Note orientation of stud offset when removing, correct offset is above rod.

9. Raise draft arms to transport position:

- a. Pull and hold lift pedal by hand.
- b. Unlock lift latch handle.
- c. Push lift pedal downward.
- d. Pull up latch handle to lock draft arms in transport position.

10. Slide mower out from under the machine.

### Installing Mower (38 in.) SN -020000

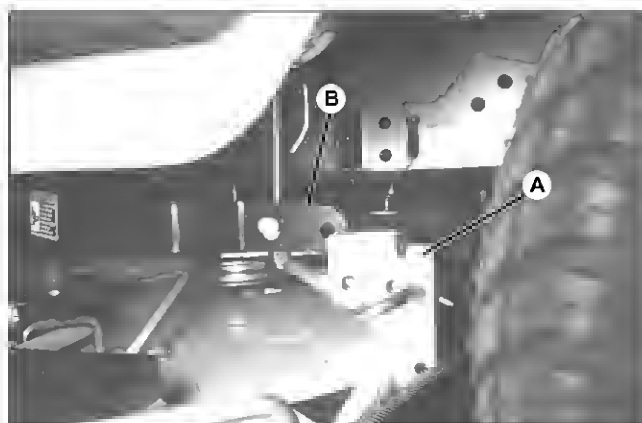
1. Park machine safely. See "Parking Safely" in Safety section.
2. Allow engine and muffler to cool completely.



**Caution: Avoid Injury! Rotating blades are dangerous. Before adjusting or servicing mower:**

- Disconnect spark plug wire(s) or battery negative (-) cable to prevent engine from starting accidentally.
- Always wear gloves when handling mower blades or working near blades.

3. Adjust mower cutting height to lowest position.



MX36289

**Picture Note: This deck used on machines through SN -040000)**

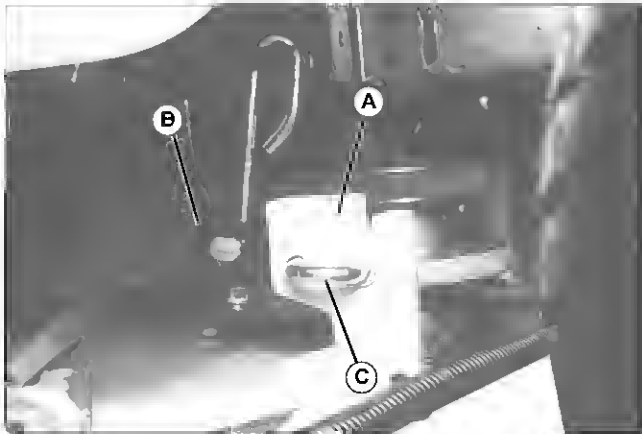
4. Slide mower deck under tractor and line up deck bracket (A) with draft arm (B).
5. Unlock lift latch handle.



**Caution: Avoid Injury! Lift pedal is spring-assisted: it may have unexpected movement. Lock lift pedal when installing or removing mower deck.**

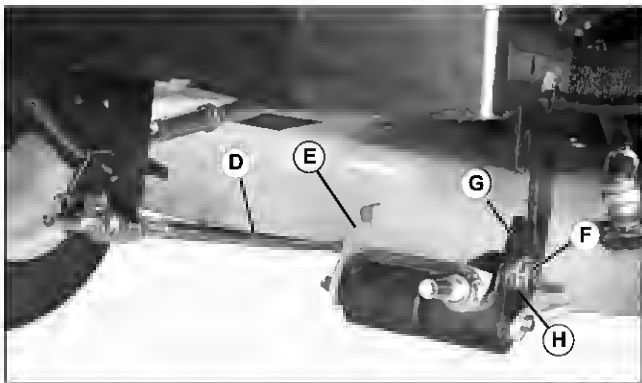
6. Pull lift pedal by hand to lower draft arms. Hold pedal securely and lock lift latch handle.

## ATTACHMENTS REPAIR



MX36288

7. Pull back J-pin (C) and insert through deck bracket (A) and draft arm (B). Make sure pin installs completely through deck bracket. Repeat for other side.



MX36204

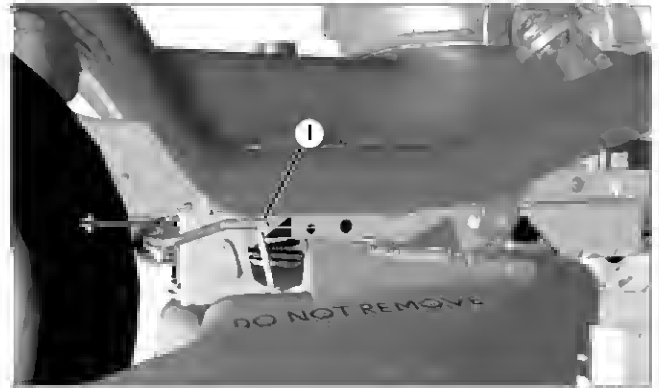
8. Install front draft rod (D) into mower bracket (E).

If draft rod assembly has been removed from machine:

- Install mounting stud (F) into draft bracket (G) at each side. Note orientation of stud offset when installing, correct orientation is for stud to be offset above draft rod.
- Secure each side with locking clip (H).
- Install draft rod into mower bracket.



**Caution: Avoid Injury!** Belt tension rod is spring-assisted and under tension. Keep a secure grasp on rod at all times while releasing or applying drive belt tension.



MX36283

9. Grasp tension rod (I) securely, and push and hold tension rod rearward, while installing mower belt onto engine sheave.

10. Level mower.

### Removing Mower (38 in.) SN 020001-

- Park machine safely. See "Parking Safely" in the Safety section.
- Allow engine and muffler to cool completely.



**Caution: Avoid Injury!** Rotating blades are dangerous. Before adjusting or servicing mower:

- Disconnect spark plug wire(s) or battery negative (-) cable to prevent engine from starting accidentally.
- Always wear gloves when handling mower blades or working near blades.

- Adjust mower cutting height to lowest position.



**Caution: Avoid Injury!** Lift pedal is spring-assisted and may have unexpected movement. Lock lift pedal when installing or removing mower deck.

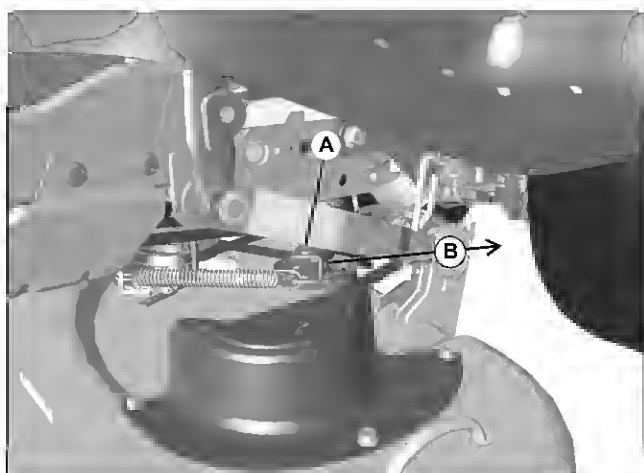
*Note: If the machine is equipped with a lift assist spring, lower the deck and then pull lift pedal back by hand to lock the lift lever.*

- Lower mower deck, pull back lift pedal by hand, and pull lift lever up to lock.



**Caution: Avoid Injury!** Belt tension arm is spring-assisted and under tension. Keep a secure grasp at all times while releasing or applying drive belt tension.

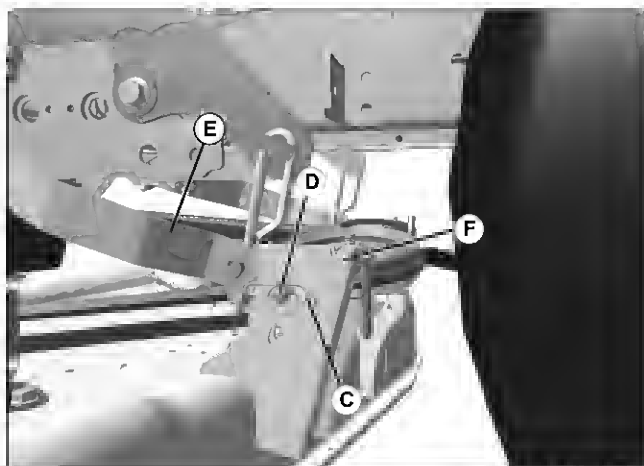
# ATTACHMENTS REPAIR



MX37955

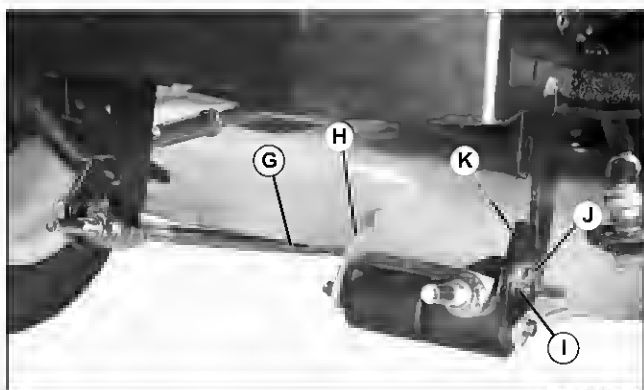
**This deck used on machines starting SN 040001-)**

5. Using a 3/8 in. ratchet, insert in square hole of tension arm (A) to rotate and hold rearward (B) under left side of fender deck, while removing mower belt from engine sheave.



MX37956

6. Remove locking clip (C) and pin (D), and move rear draft arm (E) away from deck bracket (F). Raise deck slightly with deck handle to remove pressure on pin when pulling out. Repeat on other side.



MX36204

7. Remove front draft rod (G) from machine bracket (H).
8. When operating the machine without the mower deck:
  - Remove locking clip (I) from stud (J) on each side, and remove front draft rod from draft bracket (K). Note orientation of stud offset when removing, correct offset is above rod.
9. Raise draft arms to transport (highest) position:
  - a. Pull and hold lift pedal by hand.
  - b. Unlock lift latch handle.
  - c. Push lift pedal downward.
  - d. Pull up latch handle to lock draft arms in transport position.
10. Slide mower out from under the machine.

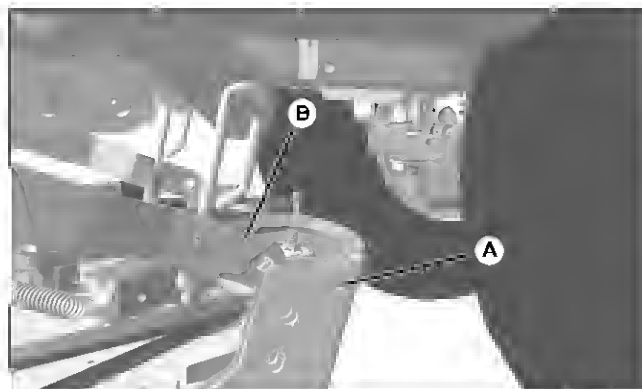
## Installing Mower (38 in.) SN 020001-

1. Park machine safely. See "Parking Safely" in the Safety section.
2. Allow engine and muffler to cool completely.



**Caution: Avoid Injury! Rotating blades are dangerous. Before adjusting or servicing mower:**

- Disconnect spark plug wire(s) or battery negative (-) cable to prevent engine from starting accidentally.
- Always wear gloves when handling mower blades or working near blades.



MX37959

**Picture Note: This deck used on machines starting SN 040001-)**

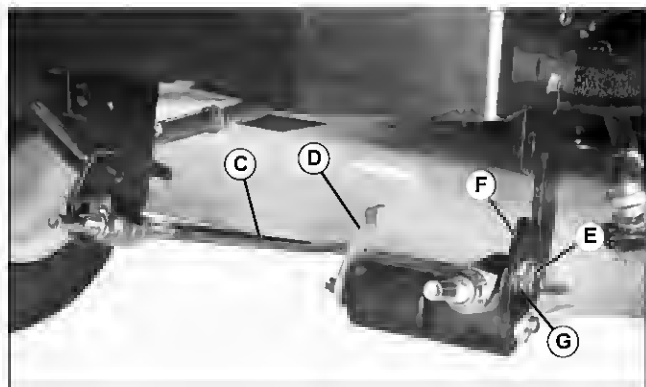
3. Slide mower deck under tractor and line up deck bracket (A) with draft arm (B).
4. Adjust mower cutting height to lowest position.
5. Unlock lift latch handle.

## ATTACHMENTS REPAIR



**Caution: Avoid Injury! Lift pedal is spring-assisted: it may have unexpected movement. Lock lift pedal when installing or removing mower deck.**

6. Pull lift pedal by hand to lower draft arms. Hold pedal securely and lock lift latch handle.

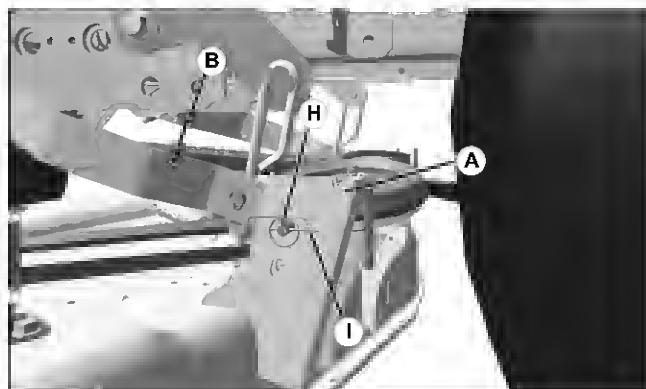


MX36204

7. Install front draft rod (C) into mower bracket (D).

If draft rod assembly has been removed from machine:

- Install mounting stud (E) into draft bracket (F) at each side. Note orientation of stud offset when installing, correct orientation is for stud to be offset above draft rod.
- Secure each side with locking clip (G).
- Install draft rod into mower bracket.



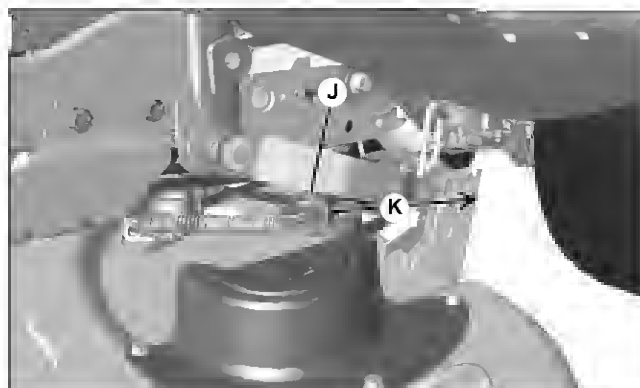
MX37956

8. Install pin (H) through deck bracket (A) and draft arm (B). Make sure pin installs completely through deck bracket. Secure pin with locking clip (I). Repeat for other side.



**Caution: Avoid Injury! Belt tension rod is spring-assisted and under tension. Keep a secure grasp on rod at all times while releasing or applying drive belt tension.**

**Important: Avoid Damage! The belt will be damaged if installed wrong. Route the belt properly through belt guides. See belt routing label on mower deck.**



MX37955

9. Using a 3/8 in. ratchet, rotate and hold tension arm (J), under left side of fender deck, rearward (K), while installing mower belt onto engine sheave.

10. Level mower.

### Removing Mower (42 in.)

- Park machine safely. See "Parking Safely" in Safety section.
- Allow engine and muffler to cool completely.



**Caution: Avoid Injury! Rotating blades are dangerous. Before adjusting or servicing mower:**

- Disconnect spark plug wire(s) or battery negative (-) cable to prevent engine from starting accidentally.
- Always wear gloves when handling mower blades or working near blades.

3. Adjust mower cutting height to lowest position.



**Caution: Avoid Injury! Lift pedal is spring-assisted and may have unexpected movement. Lock lift pedal when installing or removing mower deck.**

**Note: Because a lift assist is installed on your**

## ATTACHMENTS REPAIR

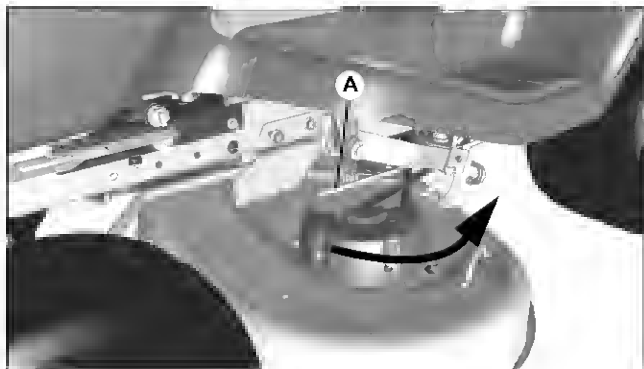
*machine, you may need to lower deck and then pull lift pedal back by hand to lock the lift lever.*

- Lower mower deck, pull back lift pedal by hand, and pull lift pedal lever to lock.



**Caution: Avoid Injury!** Belt tension rod is spring-assisted and under tension. Keep a secure grasp on rod at all times while releasing or applying drive belt tension.

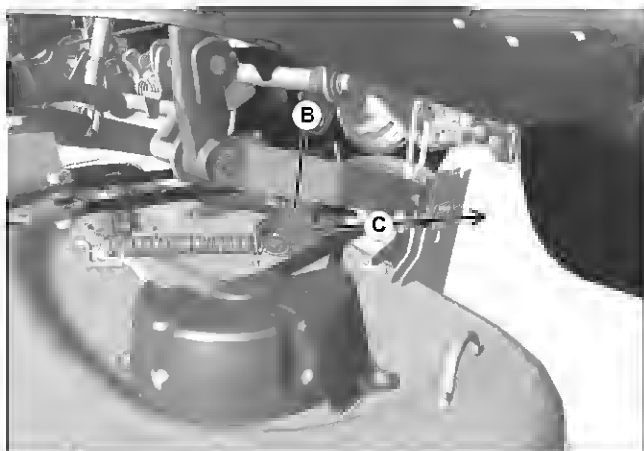
- Disconnect mower drive belt:



MX36284

**42 in. mower (SN -020000). Lever on left side.**

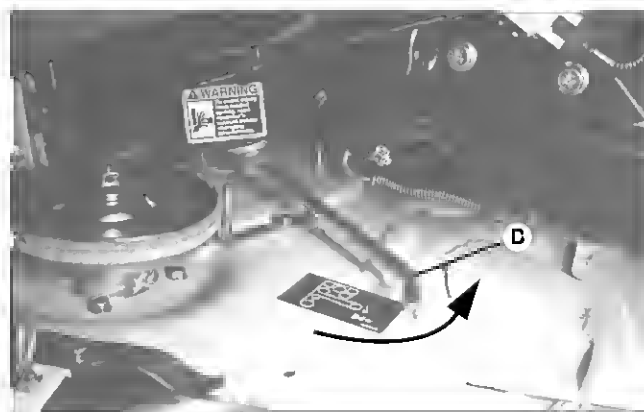
- 42 in. mower- Grasp tension rod (A) securely, and pull and hold tension rod counterclockwise, while removing mower belt from engine sheave.



MX37957

**42 mower (later models). Lever on left side.**

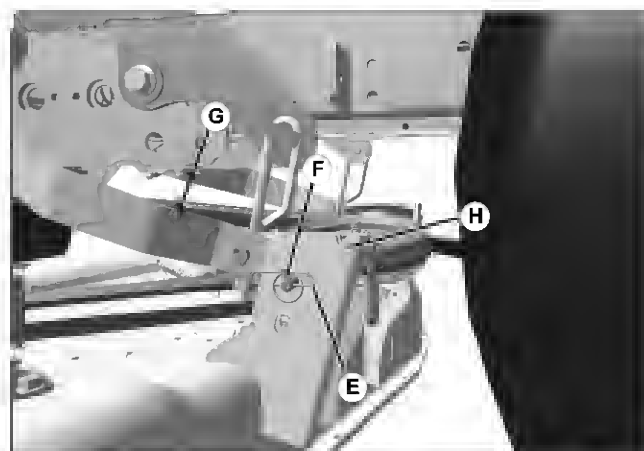
- 42 mower - Using a 3/8 in. ratchet, insert in square hole of tension arm (B) to rotate and hold rearward (C) under left side of fender deck, while removing mower belt from engine sheave.



MX36288

**42 in. mulching mower. Lever on right side.**

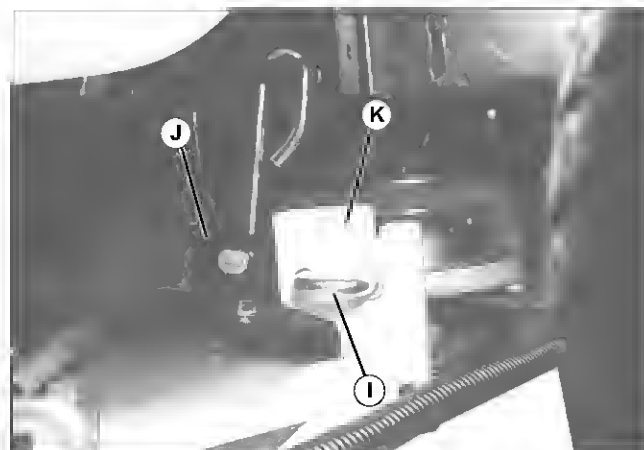
- 42 in. mulching mower- Grasp tension rod (D) securely, and pull and hold tension rod counterclockwise, while removing mower belt from engine sheave.



MX37956

**42 mower (later models). Lever on left side.**

- Remove locking clip (E) and pin (F), and move rear draft arm (G) away from deck bracket (H). Raise deck slightly with deck handle to remove pressure on pin when pulling out. Repeat on other side.

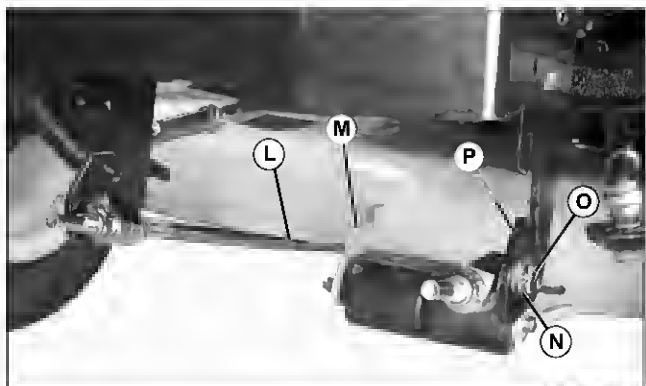




# ATTACHMENTS REPAIR

MX36288

7. Pull and rotate J-pin (I) to release and move rear draft arm (J) away from deck bracket (K). Raise deck slightly via handle to remove pressure on pin when pulling out. Repeat on other side.



MX36204

8. Remove front draft rod (L) from machine bracket (M).
9. When operating the machine without the mower deck:
- Remove locking clip (N) from stud (O) on each side, and remove front draft rod from draft bracket (P). Note orientation of stud offset when removing, correct offset is above rod.
10. Raise draft arms to transport position:
- a. Pull and hold lift pedal by hand.
  - b. Unlock lift latch handle.
  - c. Push lift pedal downward.
  - d. Pull up latch handle to lock draft arms in transport position.
11. Slide mower out from under the machine.

## Installing Mower (42 in.)

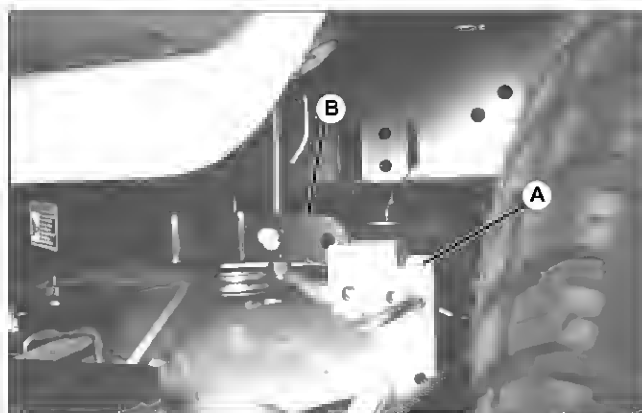
1. Park machine safely. See "Parking Safely" in Safety section.
2. Allow engine and muffler to cool completely.



**Caution: Avoid Injury! Rotating blades are dangerous. Before adjusting or servicing mower:**

- **Disconnect spark plug wire(s) or battery negative (-) cable to prevent engine from starting accidentally.**
- **Always wear gloves when handling mower blades or working near blades.**

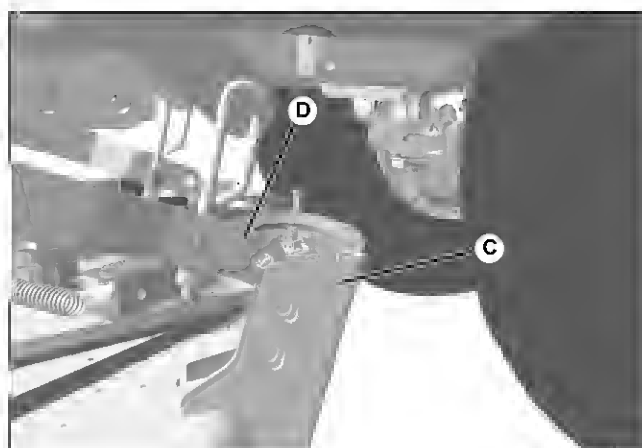
3. Adjust mower cutting height to lowest position.



MX36289

**SN -020000**

4. Slide mower deck under tractor and line up deck bracket (A) with draft arm (B).



MX37959

**SN 020001-**

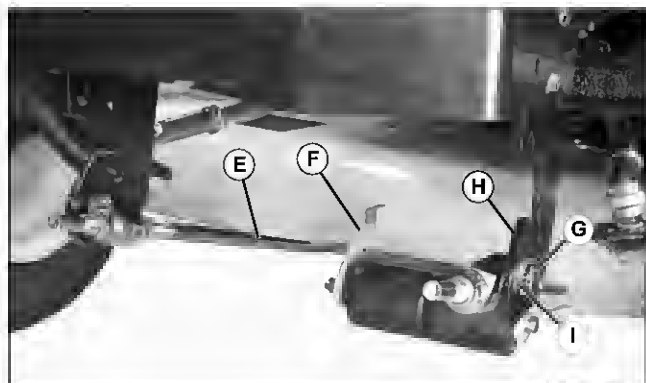
5. Slide mower deck under tractor and line up deck bracket (C) with draft arm (D).
6. Unlock lift latch handle.

## ATTACHMENTS REPAIR



**Caution: Avoid Injury! Lift pedal is spring-assisted: it may have unexpected movement. Lock lift pedal when installing or removing mower deck.**

7. Pull lift pedal by hand to lower draft arms. Hold pedal securely and lock lift latch handle.

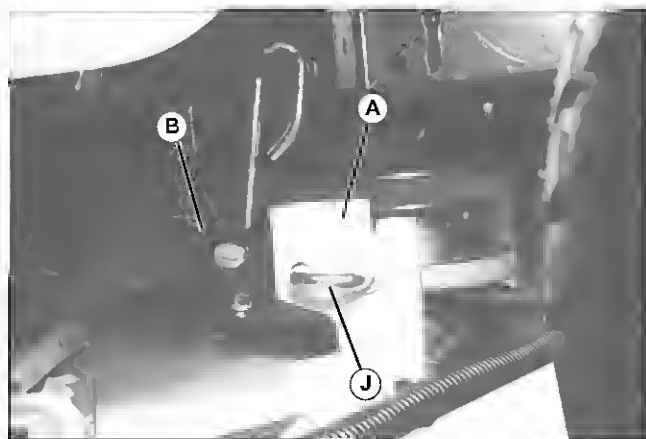


MX36204

8. Install front draft rod (E) into mower bracket (F).

If draft rod assembly has been removed from machine:

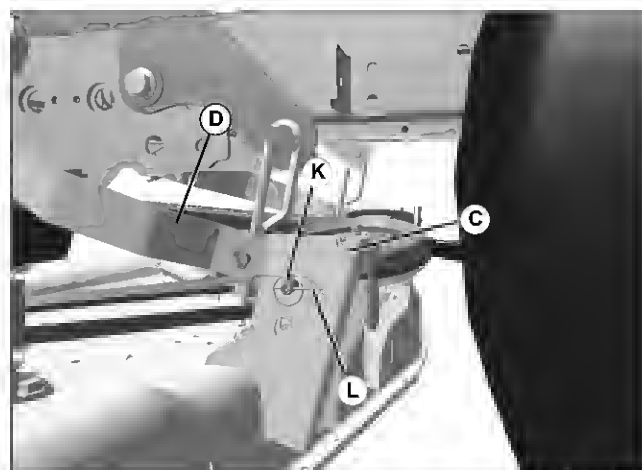
- Install mounting stud (G) into draft bracket (H) at each side. Note orientation of stud offset when installing, correct orientation is for stud to be offset above draft rod.
- Secure each side with locking clip (I).
- Install draft rod into mower bracket.



MX36288

**SN -020000**

9. Pull back J-pin (J) and insert through deck bracket (A) and draft arm (B). Make sure pin installs completely through deck bracket. Repeat for other side.



MX37956

**SN 020001-**

10. Install pin (K) through deck bracket (C) and draft arm (D). Make sure pin installs completely through deck bracket. Secure pin with locking clip (L). Repeat for other side.



**Caution: Avoid Injury! Belt tension rod is spring-assisted and under tension. Keep a secure grasp on rod at all times while releasing or applying drive belt tension.**

**Important: Avoid Damage! The belt will be damaged if installed wrong. Route the belt properly through belt guides. See belt routing label on mower deck.**

11. Install mower drive belt:

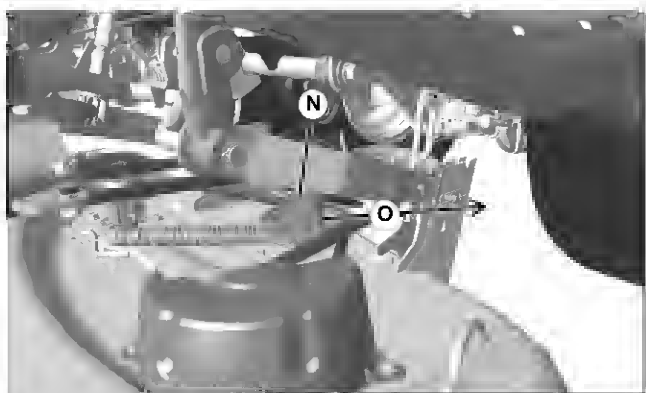


MX36284

**42 in. mower (SN -020000). Lever on left side.**

- 42 in. mower - Grasp tension rod (M) securely, and pull and hold tension rod counterclockwise, while installing mower belt onto engine sheave.

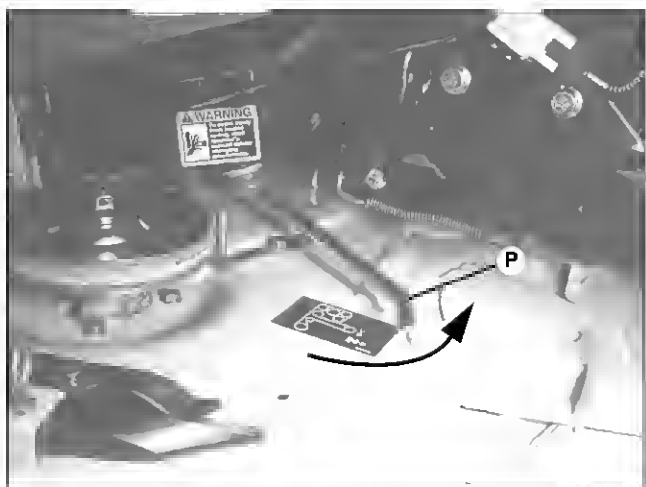
## ATTACHMENTS REPAIR



MX37957

**42 mower (SN 020001-). Lever on left side.**

- 42 mower - Using a 3/8 in. ratchet, insert in square hole of tension arm (N) to rotate and hold rearward (O) under left side of fender deck, while removing mower belt from engine sheave.



MX36285

**42 in. mulching mower. Lever on right side.**

- 42 in. mulching mower - Grasp tension rod (P) securely, and pull and hold tension rod counterclockwise, while installing mower belt onto engine sheave.

12. Level mower.

### Removing Mower (48 Single Belt Drive Mower)

1. Park machine safely. See "Parking Safely" in the Safety section.
2. Allow engine and muffler to cool completely.



**Caution: Avoid Injury! Rotating blades are dangerous. Before adjusting or servicing mower:**

- Disconnect spark plug wire(s) or battery negative (-) cable to prevent engine from starting accidentally.
- Always wear gloves when handling mower blades or working near blades.

3. Adjust mower cutting height to lowest position.



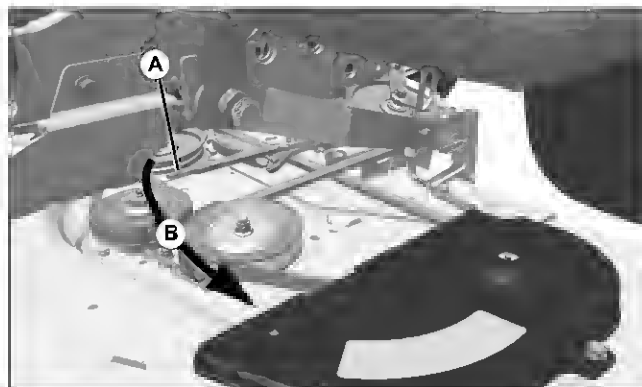
**Caution: Avoid Injury! Lift pedal is spring-assisted and may have unexpected movement. Lock lift pedal when installing or removing mower deck.**

*Note: Because a lift assist may be installed on your machine, you will need to lower deck and then pull lift pedal back by hand to lock the lift lever.*

4. Lower mower deck, pull back lift pedal by hand, and pull lift lever up to lock.



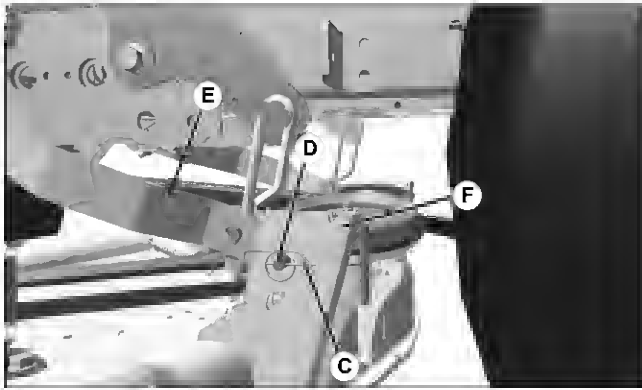
**Caution: Avoid Injury! Belt tension rod is spring-assisted and under tension. Keep a secure grasp on rod at all times while releasing or applying drive belt tension.**



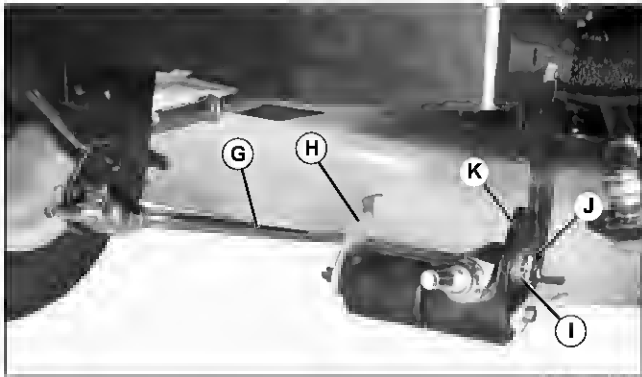
MX37999

5. Using a 3/8 in. ratchet, insert in square hole of tension arm (A) to rotate and hold rearward (B) under left side of fender deck, while removing mower belt from engine sheave.

## ATTACHMENTS REPAIR



6. Remove locking clip (C) and pin (D), and move rear draft arm (E) away from deck bracket (F). Raise deck slightly with deck handle to remove pressure on pin when pulling out. Repeat on other side.



7. Remove front draft rod (G) from mower bracket (H).
8. When operating the machine without the mower deck:
- Remove locking clip (I) from stud (J) on each side, and remove front draft rod from draft bracket (K). Note orientation of stud offset when removing, correct offset is above rod.
9. Raise draft arms to transport position:
- a. Pull and hold lift pedal by hand.
  - b. Unlock lift latch handle.
  - c. Push lift pedal downward.
  - d. Pull up latch handle to lock draft arms in transport position.
10. Slide mower out from under the machine.

### Installing Mower (48 Single Belt Drive Mower)

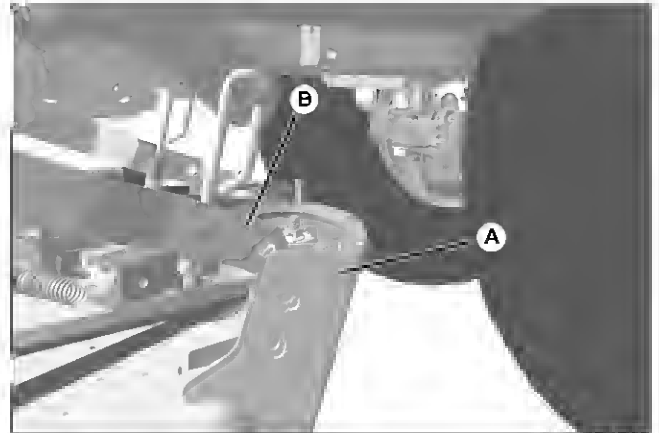
1. Park machine safely. See "Parking Safely" in the Safety section.
2. Allow engine and muffler to cool completely.



**Caution: Avoid Injury! Rotating blades are dangerous. Before adjusting or servicing mower:**

- **Disconnect spark plug wire(s) or battery negative (-) cable to prevent engine from starting accidentally.**
- **Always wear gloves when handling mower blades or working near blades.**

3. Adjust mower cutting height to lowest position.



4. Slide mower deck under tractor and line up deck bracket (A) with draft arm (B).
5. Unlock lift latch handle.

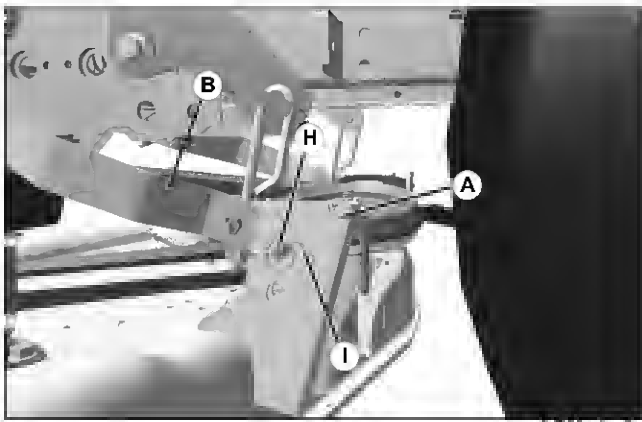


**Caution: Avoid Injury! Lift pedal is spring-assisted: it may have unexpected movement.**

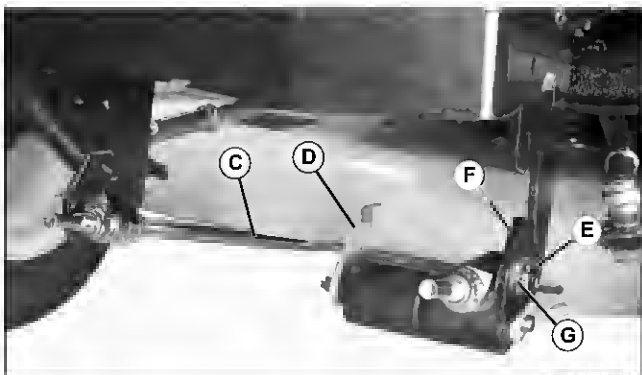
**Lock lift pedal when installing or removing mower deck.**

6. Pull lift pedal by hand to lower draft arms. Hold pedal securely and lock lift latch handle.

## ATTACHMENTS REPAIR



7. Install pin (H) through deck bracket (A) and draft arm (B). Make sure pin installs completely through deck bracket. Secure pin with locking clip (I). Repeat for other side.



8. Install front draft rod (C) into mower bracket (D).

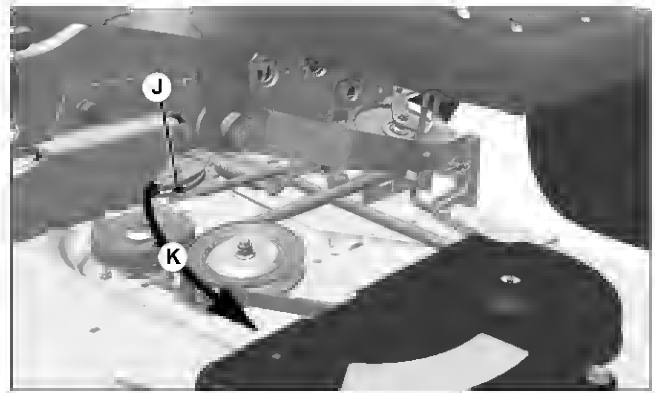
If draft rod assembly has been removed from machine:

- Install mounting stud (E) into draft bracket (F) at each side. Note orientation of stud offset when installing, correct orientation is for stud to be offset above draft rod.
- Secure each side with locking clip (G).
- Install draft rod into mower bracket.



**Caution: Avoid Injury!** Belt tension rod is spring-assisted and under tension. Keep a secure grasp on rod at all times while releasing or applying drive belt tension.

**Important: Avoid Damage!** The belt will be damaged if installed wrong. Route the belt properly through belt guides. See belt routing label on mower deck.



9. Using a 3/8 in. ratchet, rotate and hold tension arm (J), under left side of fender deck, counterclockwise (K), while installing mower belt onto engine sheave.

10. Level mower.

### Removing Mower (48 and 54 Two Belt Drive Mowers)

- Park machine safely. See "Parking Safely" in Safety section.
- Allow engine and muffler to cool completely.



**Caution: Avoid Injury!** Rotating blades are dangerous. Before adjusting or servicing mower:

- Disconnect spark plug wire(s) or battery negative (-) cable to prevent engine from starting accidentally.
- Always wear gloves when handling mower blades or working near blades.

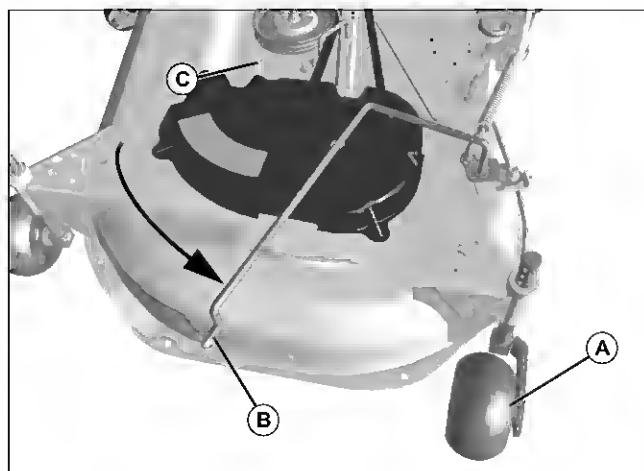
3. Adjust mower cutting height to lowest position.



**Caution: Avoid Injury!** Lift pedal is spring-assisted and may have unexpected movement. Lock lift pedal when installing or removing mower deck.

**Note:** Because a lift assist is installed on your machine, you may need to lower deck and then pull lift pedal back by hand to lock the lift lever.

## ATTACHMENTS REPAIR



MX37958

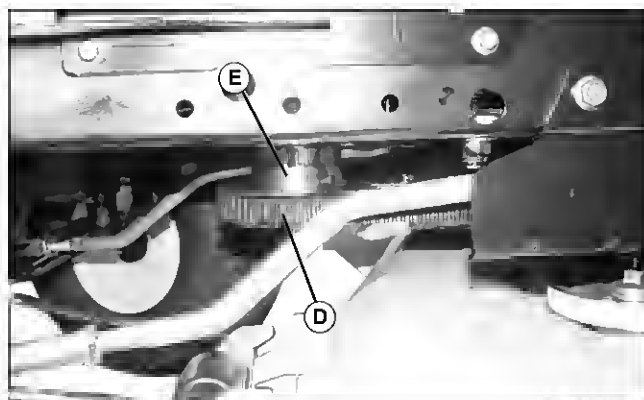
**Picture Note: 54 mower shown. Lever on left side.**

4. Rotate all mower gage wheels to allow mower deck to be rolled outward away from machine:
  - a. Remove locking pin and pin from gage wheel shaft.
  - b. Rotate mower wheel (A) 90°, as shown.
  - c. Repeat for all gage wheels.
5. Lower mower deck, pull back lift pedal by hand, and pull lift lever up to lock.



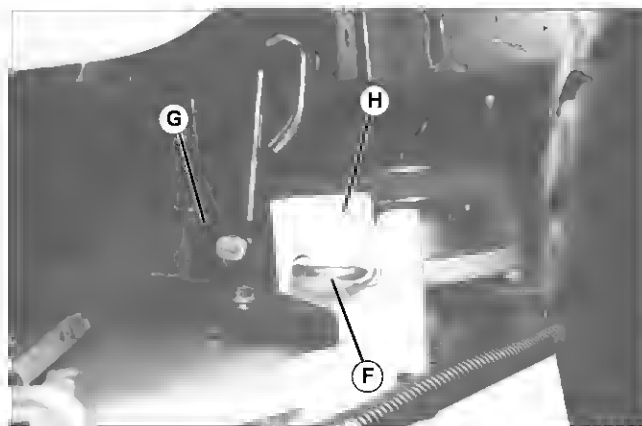
**Caution: Avoid Injury! Belt tension rod is spring-assisted and under tension. Keep a secure grasp on rod at all times while releasing or applying drive belt tension.**

6. Grasp and hold tension rod (B) securely. Disengage rod from retaining bracket (C) by rotating rod counterclockwise. Move rod as far as possible toward rear wheel to remove all belt tension.



MX36287

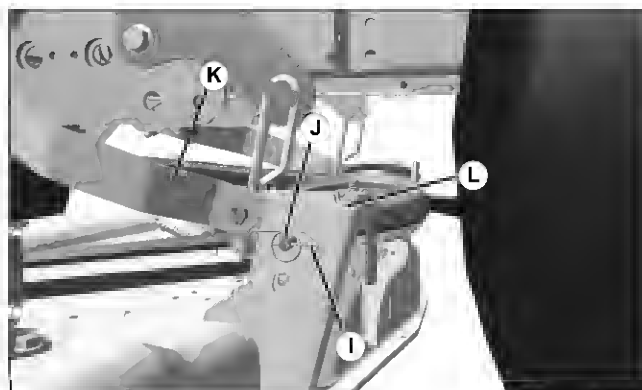
7. Remove separate drive belt (D) from engine sheave (E), and move tension rod back into retaining bracket.



MX36288

**Picture Note: SN -020000**

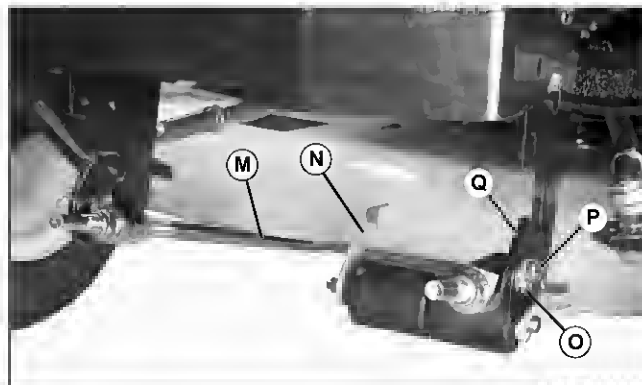
8. Pull and rotate J-pin (F) to release and move rear draft arm (G) away from deck bracket (H). Raise deck slightly via handle to remove pressure on pin when pulling out. Repeat on other side.



MX37956

**Picture Note: SN 020001-**

9. Remove locking clip (I) and pin (J), and move rear draft arm (K) away from deck bracket (L). Raise deck slightly with deck handle to remove pressure on pin when pulling out. Repeat on other side.



MX36204

10. Remove front draft rod (M) from machine bracket (N).
11. When operating the machine without the mower deck:

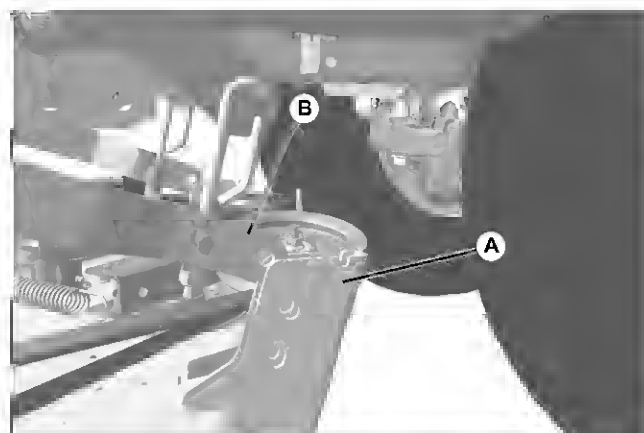
## ATTACHMENTS REPAIR

- Remove locking clip (O) from stud (P) on each side, and remove front draft rod from draft bracket (Q). Note orientation of stud offset when removing, correct offset is above rod.

12. Raise draft arms to transport position:

- a. Pull and hold lift pedal by hand.
- b. Unlock lift latch handle.
- c. Push lift pedal downward.
- d. Pull up latch handle to lock draft arms in transport position.

13. Slide mower out from under the machine.



MX37959

### Installing Mower (48 and 54 Two Belt Drive Mowers)

1. Park machine safely. See "Parking Safely" in Safety section.

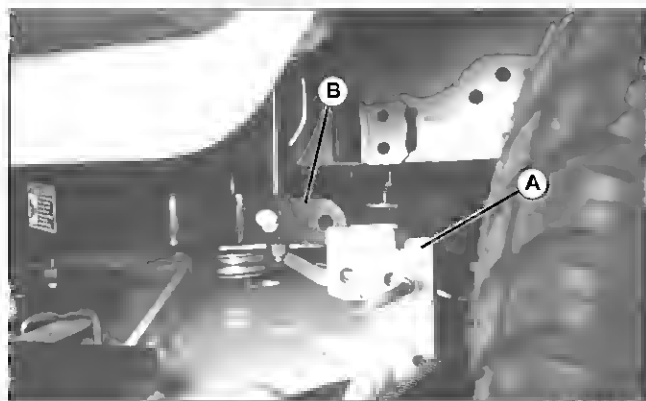
2. Allow engine and muffler to cool completely.



**Caution: Avoid Injury! Rotating blades are dangerous. Before adjusting or servicing mower:**

- Disconnect spark plug wire(s) or battery negative (-) cable to prevent engine from starting accidentally.
- Always wear gloves when handling mower blades or working near blades.

3. Adjust mower cutting height to lowest position.



MX36289

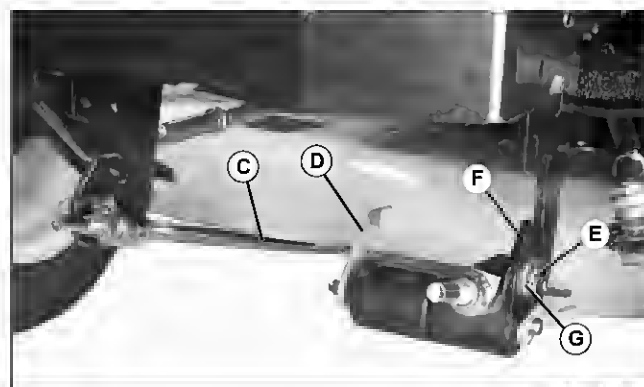
4. Slide mower deck under tractor and line up deck bracket (A) with draft arm (B).

5. Unlock lift latch handle.



**Caution: Avoid Injury! Lift pedal is spring-assisted: it may have unexpected movement. Lock lift pedal when installing or removing mower deck.**

6. Pull lift pedal by hand to lower draft arms. Hold pedal securely and lock lift latch handle.



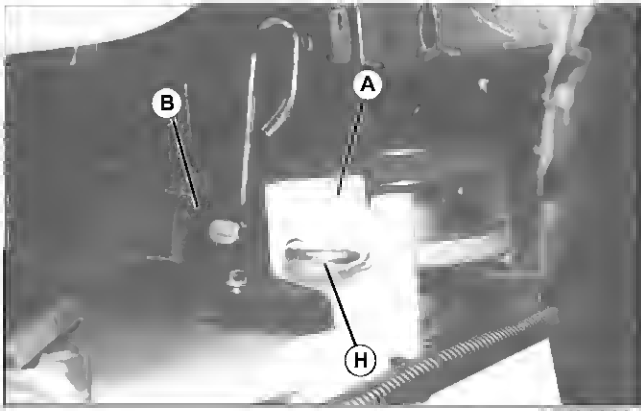
MX36204

7. Install front draft rod (C) into mower bracket (D).

If draft rod assembly has been removed from machine:

- a. Install mounting stud (E) into draft bracket (F) at each side. Note orientation of stud offset when installing, correct orientation is for stud to be offset above draft rod.
- b. Secure each side with locking clip (G).
- c. Install draft rod into mower bracket.

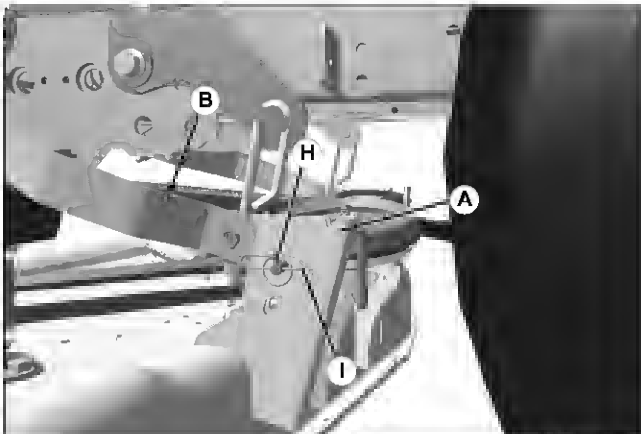
## ATTACHMENTS REPAIR



MX36288

**Picture Note:** SN -020000 mower shown.

8. Pull back J-pin (H) and insert through deck bracket (A) and draft arm (B). Make sure pin installs completely through deck bracket. Repeat for other side.



MX37956

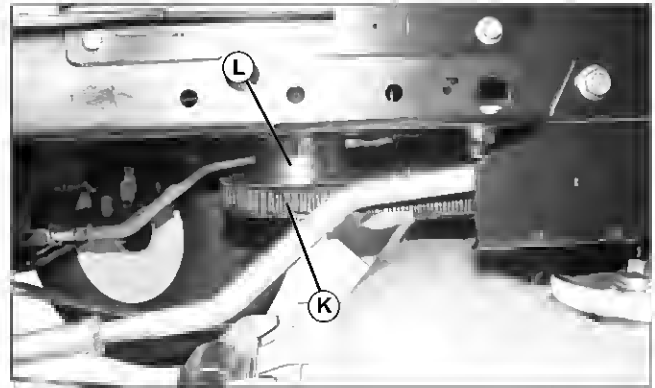
**Picture Note:** SN 020001- mower shown.

9. Install pin (H) through deck bracket (A) and draft arm (B). Make sure pin installs completely through deck bracket. Secure pin with locking clip (I). Repeat for other side.



**Caution: Avoid Injury!** Belt tension rod is spring-assisted and under tension. Keep a secure grasp on rod at all times while releasing or applying drive belt tension.

**Important: Avoid Damage!** The belt will be damaged if installed wrong. Route the belt properly through belt guides. See belt routing label on mower deck.

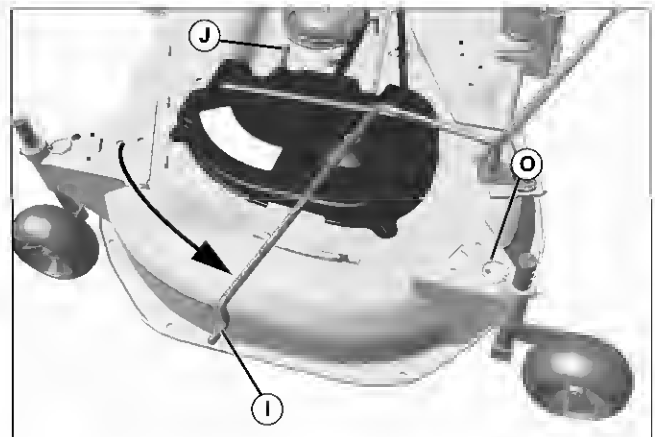


MX36287



MX36286

**Picture Note:** SN -020000 48 in. mower shown. Lever on left side.



MX37960

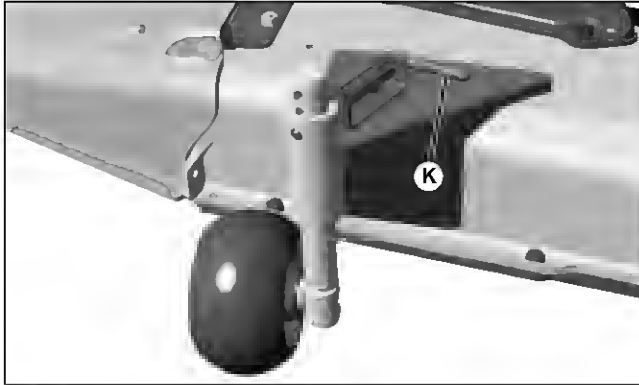
**Picture Note:** SN 020001- 54 in. mower shown. Lever on left side.

10. Grasp and hold tension rod (I) securely. Disengage rod from retaining bracket (J) by rotating rod counterclockwise. Move rod as far as possible toward rear wheel. Install separate drive belt (K) onto mower deck and engine sheave (L), and move tension rod back into retaining bracket.



# ATTACHMENTS REPAIR

11. Level mower.

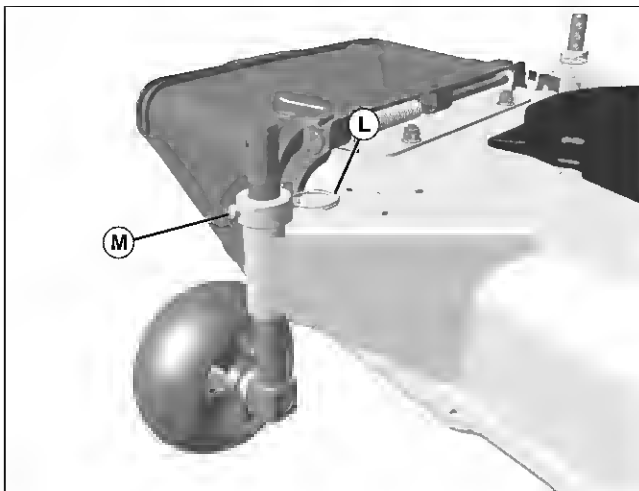


MX8332

**Picture Note: 54 in. model shown.**

12. Raise the deck to cutting height and rotate all mower wheels to operation position:

- SN -020000: Pull pin (K) outward and move wheel to proper hole position. Release pin to lock wheel in position.



MX37948

**Picture Note: 48 mower shown.**

- SN 020001-: Remove locking clip (L) and pin (M), and move wheel to proper hole position. Install pin and locking clip to secure wheels in position.

## Removing and Installing Machine Shields - Export Machines

### Remove and Install Machine Shields

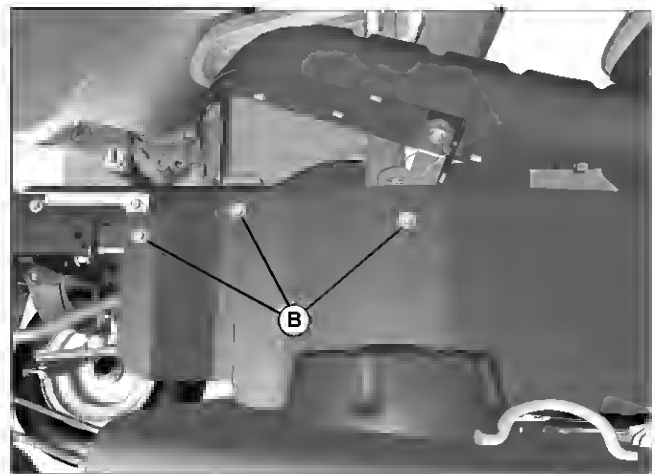
1. Park machine safely. See "Parking Safely" in Safety section



MX41216

**Left side shield shown.**

2. Remove one screw (A) from the rear of the left and right machine shields.

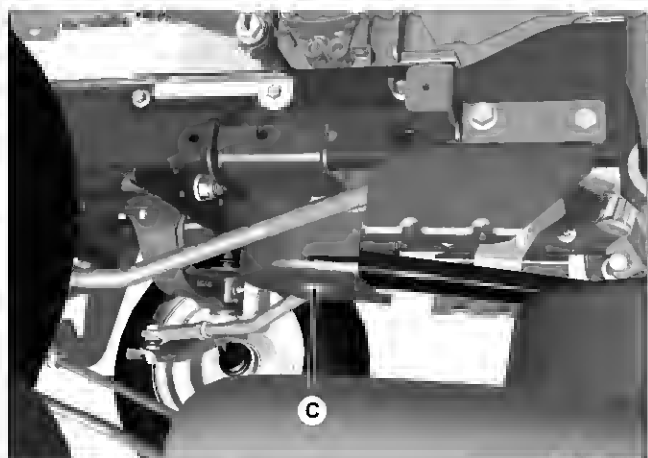


MX42964

3. Remove three screws (B) from the left machine shield, and remove the shield from the machine.

4. Repeat for shield on right side of machine.

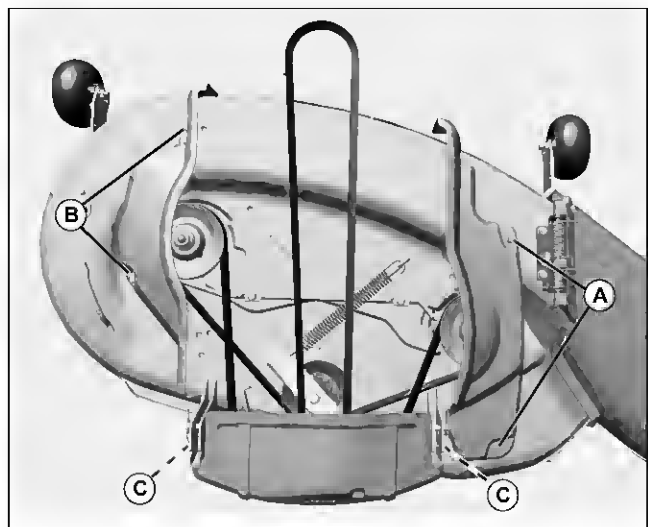
# ATTACHMENTS REPAIR



MX42963

5. Remove engine drive sheave shield (C).
6. To install machine shields:
  - a. Position drive sheave shield (C) over engine clutch, but do not fasten.
  - b. Position left machine shield on mounting bracket tab and secure with four screws (A, B).
  - c. Position right machine shield on mounting bracket tab and secure with four screws.

## Remove and Install Mower Deck Shields - 42 Mower



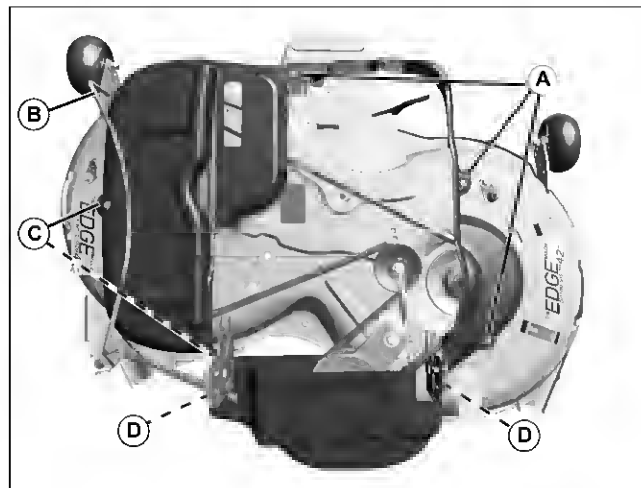
MX43913

1. Remove two screws (A) and the right shield from the deck.
2. Remove two screws (B) and the left shield from the deck.
3. Remove two screws from each side of the rear shield (C) and remove the shield.

**Note:** Any time deck shields are removed, clean all debris from the top surface of the deck and under all sheaves before shield replacement.

4. Clean top surface of mower deck and sheaves.
5. To install mower deck shields:
  - a. Position the rear shield on the deck and secure with two screws on each side (C).
  - b. Install the left deck shield and secure with two screws (B).
  - c. Install the right deck shield and secure with two screws (A).

## Remove and Install Mower Deck Shields - 42 Mulch Mower



MX43915

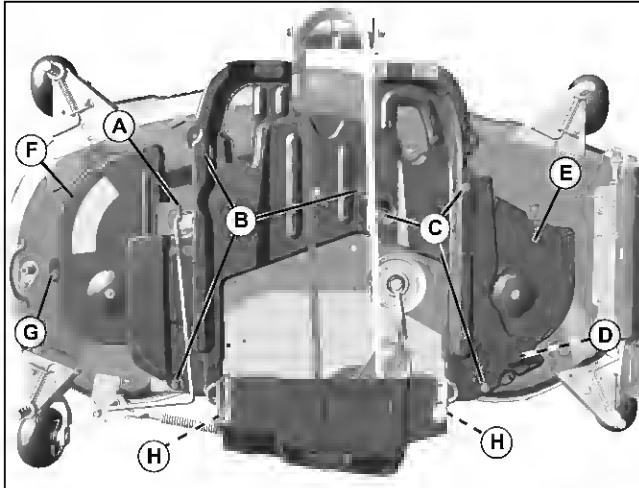
1. Remove three screws (A) and the right shield from the deck.
2. Disengage end of tension rod (B) from wheel bracket and rotate counterclockwise fully toward the rear wheel.
3. Remove two screws (C) and the left shield from the deck.
4. Remove two screws from each side of the rear shield (D) and remove the shield.

**Note:** Any time deck shields are removed, clean all debris from the top surface of the deck and under all sheaves before shield replacement.

5. Clean top surface of mower deck and sheaves.
6. To install mower deck shields:
  - a. Position the rear shield on the deck and secure with two screws on each side (D).
  - b. Install the left deck shield and secure with two screws (C).
  - c. Install the right deck shield and secure with three screws (A).
  - d. Rotate the tension rod (B) clockwise and engage the end in the deck bracket to secure.

# ATTACHMENTS REPAIR

## Remove and Install Mower Deck Shields - 48, 54 Mower



MX43806

### 48 in. deck shown.

1. Disengage end of tension rod (A) from deck bracket and rotate counterclockwise fully toward the rear wheel.
2. Remove three screws (B) and the left center deck shield.
3. Remove three screws (C) and the right center deck shield.
4. Remove one screw (D) and slide the right shield (E) to the rear and remove.
5. To remove the left deck shield (F):
  - On a 48 in. deck, remove 1 screw (G), pull the shield to the left and remove.
  - On a 54 in. deck, remove 1 screw, push the shield toward the center and remove.
6. Remove two screws from each side of the rear shield (H) and remove the shield.

**Note:** Any time deck shields are removed, clean all debris from the top surface of the deck and under all sheaves before shield replacement.

7. Clean top surface of mower deck and sheaves.
8. To install mower deck shields:
  - a. Position the rear shield on the deck and secure with two screws on each side (H).
  - b. Install the left and right deck shields and secure with one screw each (G, D).
  - c. Install the center right deck shield and secure with three screws (C).
  - d. Install the center left deck shield and secure with three screws (B).
  - e. Rotate the tension rod (A) clockwise and engage the end in the deck bracket to secure.

## Mower Blade Removal and Installation

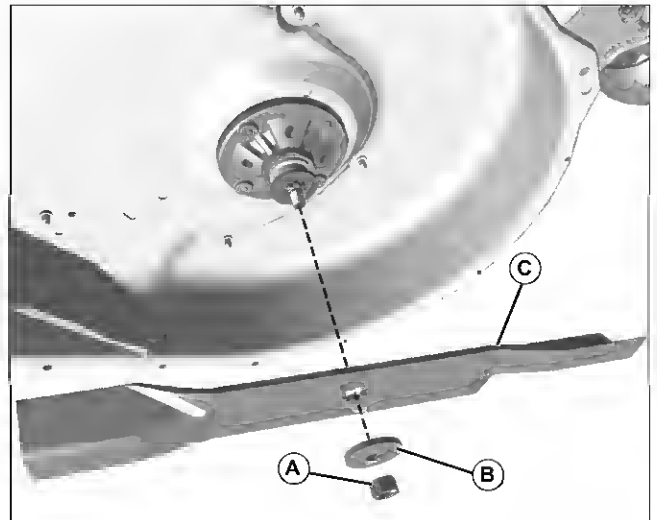


**Caution: Avoid Injury!** Rotating blades are dangerous. Before adjusting or servicing mower:

- Disconnect spark plug wire(s) or battery negative (-) cable to prevent engine from starting accidentally.
- Always wear gloves when handling mower blades or working near blades.

### Removing Mower Blades:

1. Park machine safely. See "Parking Safely" in Safety section.
2. Raise mower deck to gain access to mower blades. If necessary, remove mower deck.
3. Block mower blade with a piece of wood to prevent it from spinning.
4. Remove mower blade(s):

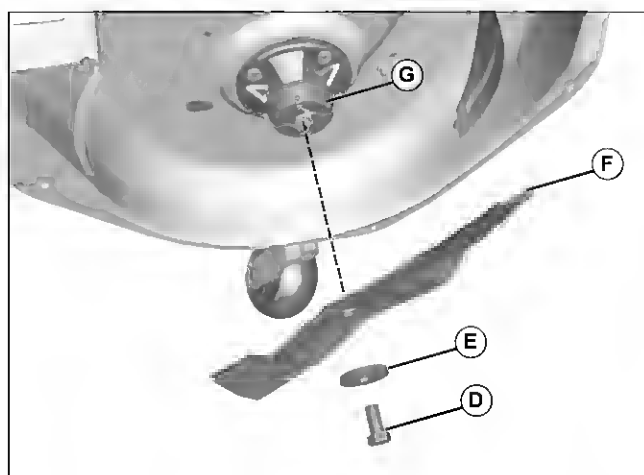


MX36276

### 38 and 42 Inch Mowers

- Loosen and remove nut (A), washer (B), and blade (C).
- Remove deflector cup (if installed)

# ATTACHMENTS REPAIR



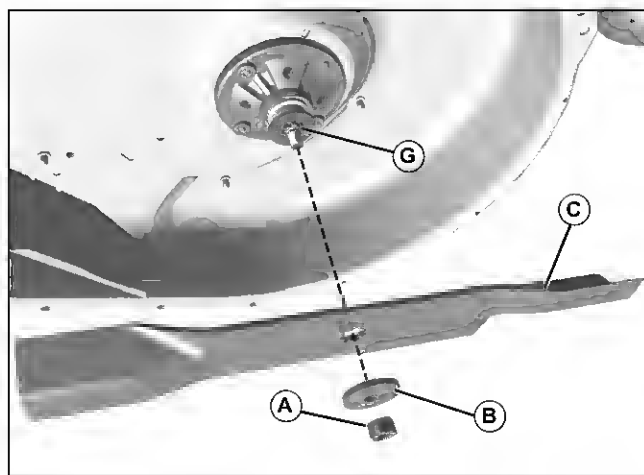
MX36300

## 48 and 54 Inch Mowers

- Loosen and remove bolt (D), washer (E), and blade (F).
  - Remove deflector cup (G).
5. Inspect blades; sharpen, balance or replace blades as necessary. Clean and inspect deflector cup.

## Installing Mower Blades: 38 and 42 Inch Mowers:

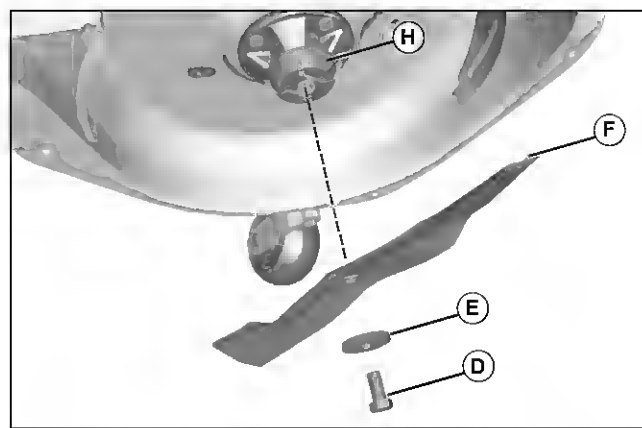
**Important: Avoid Damage!** On 42M mower, blades are marked right and left on bottom side of each blade. Make sure to install correct blade to right and left sides of deck.



MX36278

1. Align the splined center hole in the blade (C) with the splined spindle shaft (G) and put the blade onto the mower spindle shaft with cutting edge toward ground.
2. Install washer (B), with cupped side towards blade, and install nut (A) to secure blade onto splined spindle shaft
3. Block mower blade with a piece of wood to prevent spinning and tighten nut to specification.

## Installing Mower Blades: 48 and 54 Inch Mowers:



MX36300

1. Make sure deflector cup (H) is seated properly between mower spindle and blade.
2. Position mower blade (F) with cutting edge toward ground onto mower spindle.
3. Install washer (E), with cupped side towards blade, and install bolt (D) to secure blade onto spindle shaft.
4. Block mower blade with a piece of wood to prevent spinning and tighten bolt to 68 N•m (50 lb-ft).

## Torque Specifications All Decks:

Nut 12mm (38 & 42-In. Decks) . . . . . 68 N•m (50 lb-ft)  
 Lock Nut 5/8 in. (38 & 42-In. Decks) . . . 88 N•m (65 lb-ft)  
 Bolt Torque (48 & 54-In. Decks) . . . . . 68 N•m (50 lb-ft)

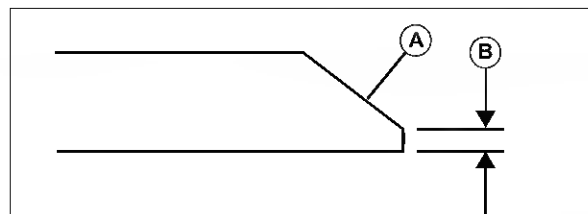
## Sharpen and Balance Blades

### Procedure:



**Caution: Avoid Injury! Wear gloves when handling blade.**

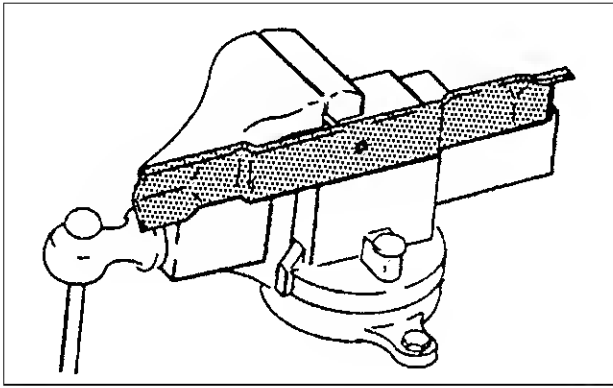
1. Clean blade.
2. Sharpen blade using grinder, file or power sharpener.



M61830

3. Do not alter original bevel (A). Blade should have **0.40 mm (0.016 in.)** cutting edge (B) rather than a razor - type edge.

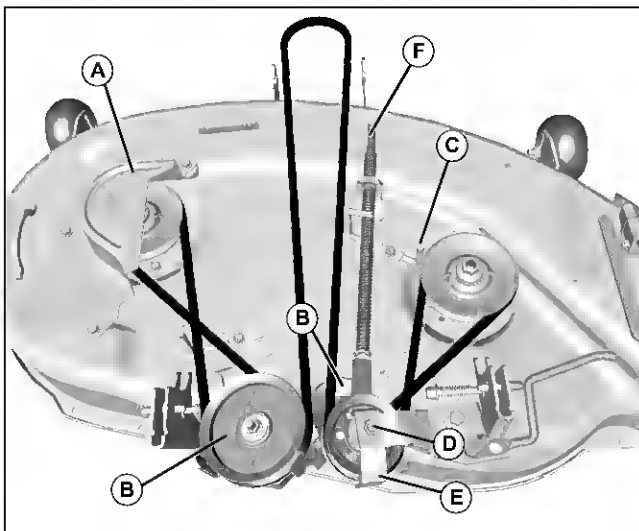
## ATTACHMENTS REPAIR



4. Put blade on nail in a vise or vertical wall stud.
5. Turn blade to horizontal position. If the blade is not balanced, the heavy end will drop.
6. Grind bevel of heavy end. Do not change blade bevel angle.

### Replacing Mower Drive Belt (38 in. Mower) SN -020000

1. Park machine safely. See "Parking Safely" in Safety section.
2. Allow engine and muffler to cool completely.
3. Remove mower deck.
4. Remove drive belt.

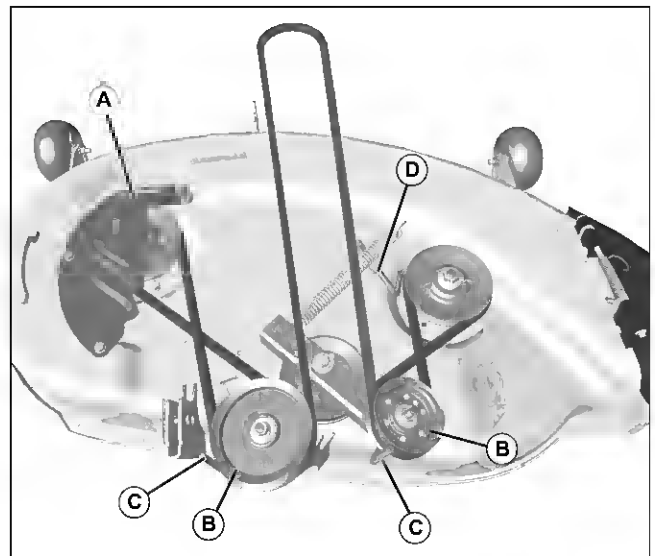


- Remove three bolts and belt shield (A).
  - Loosen hardware for two sheaves (B) and belt guide (C).
  - Remove top nut (D) and belt guide (E).
  - Remove mower belt.
5. Inspect belt for wear or damage; replace as necessary.

6. Clean top surface of mower deck and sheaves.
7. Install belt on mower deck as shown. Make sure belt is in the groove of each sheave and inside belt guide (C).
8. Tighten belt guide (C).
9. Install belt guide (E) and top nut (D).
10. Tighten sheave hardware to 47 N•m (35 lb-ft).
11. Install belt shield.
12. Install mower deck and adjust tension on mower engagement rod (F), if necessary.

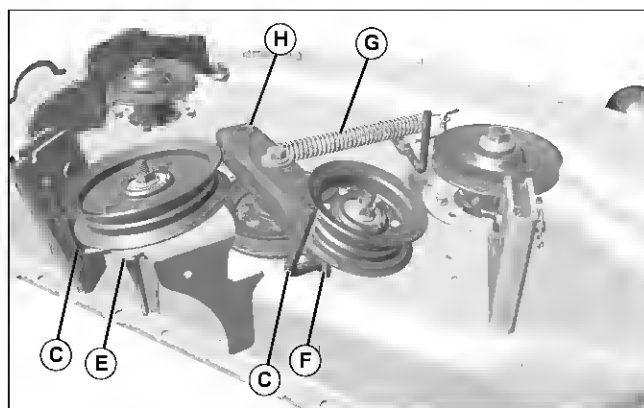
### Replacing Mower Drive Belt (38 Mower) SN 020001-

1. Park machine safely. See "Parking Safely" in the Safety section.
2. Allow engine and muffler to cool completely.
3. Remove mower deck.
4. Remove drive belt.



- Remove three bolts and belt shield (A).
  - Loosen hardware for two sheaves (B) to remove belt from belt guides (C).
  - Loosen hardware for belt guide (D).
  - Remove mower belt.
5. Inspect belt for wear or damage; replace as necessary.
  6. Clean top surface of mower deck and sheaves.
  7. Install belt on mower deck as shown. Make sure belt is in the groove of each sheave and inside belt guide (D).
  8. Tighten belt guide (D).

# ATTACHMENTS REPAIR

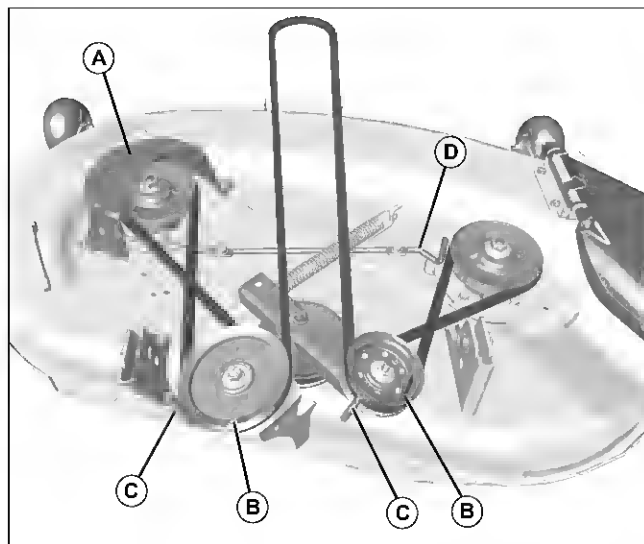


MX37951

9. Be sure belt guides (C) are in the rounded groove of deck bracket (E) and tensioning bracket (F). Tighten sheave hardware to 54 N•m (40 lb-ft).
10. Install belt shield.
11. Before installing deck, make sure tension spring (G) is installed. Rotate tension arm (H) clockwise and install spring onto bottom square hole in tension arm.

## Replacing Mower Drive Belt (42 Mower)

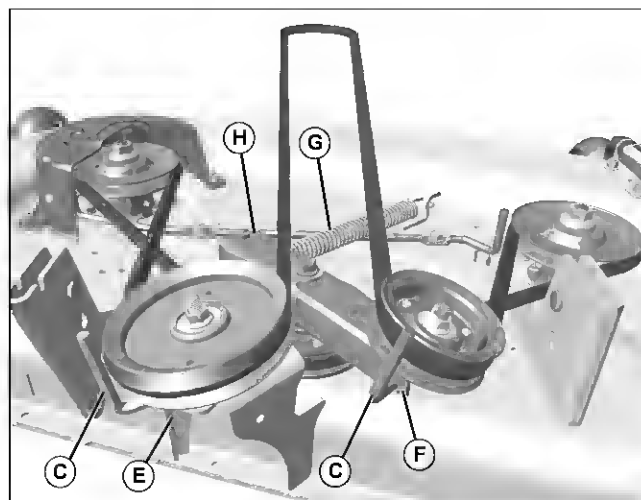
1. Park machine safely. See "Parking Safely" in Safety section.
2. Allow engine and muffler to cool completely.
3. Remove mower deck.
4. Remove drive belt.



MX37962

- Remove two bolts and belt shield (A).
- Loosen hardware for two sheaves (B) to remove belt from belt guides (C).
- Remove two bolts for belt guide (D).

- Remove mower belt.
5. Inspect belt for wear or damage; replace as necessary.
  6. Clean top surface of mower deck and sheaves.
  7. Install belt on mower deck as shown. Make sure belt is in the groove of each sheave, and on the inside of the guides at sheaves (B).
  8. Install belt guide (D) and secure with two bolts.



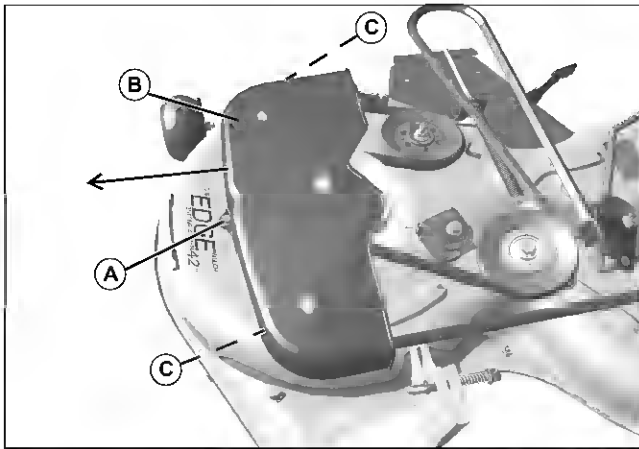
MX37952

9. Be sure belt guides (C) are in the rounded groove of deck bracket (E) and tensioning bracket (F). Tighten sheave hardware to 54 N•m (40 lb-ft).
10. Tighten sheave hardware to 54 N•m (40 lb-ft).
11. Install belt shield.
12. Before installing deck, make sure tension spring (G) is installed. Rotate tension arm (H) clockwise and install spring onto bottom square hole in tension arm.

## Replacing Mower Drive Belt (42 in. Mulching Mower)

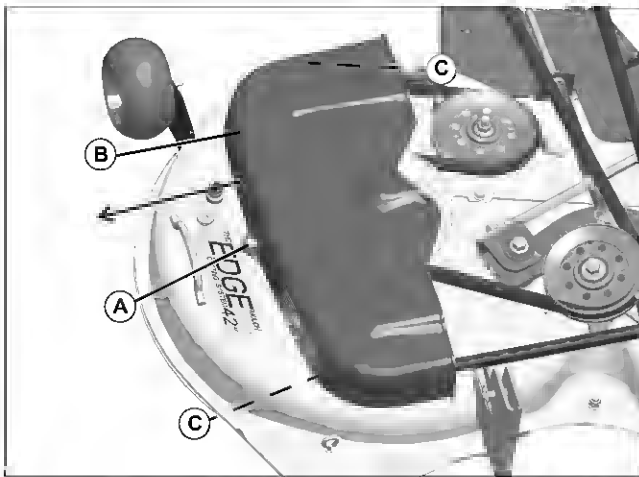
1. Park machine safely. See "Parking Safely" in Safety section.
2. Allow engine and muffler to cool completely.
3. Remove mower deck.
4. Remove drive belt:

## ATTACHMENTS REPAIR



MX36279

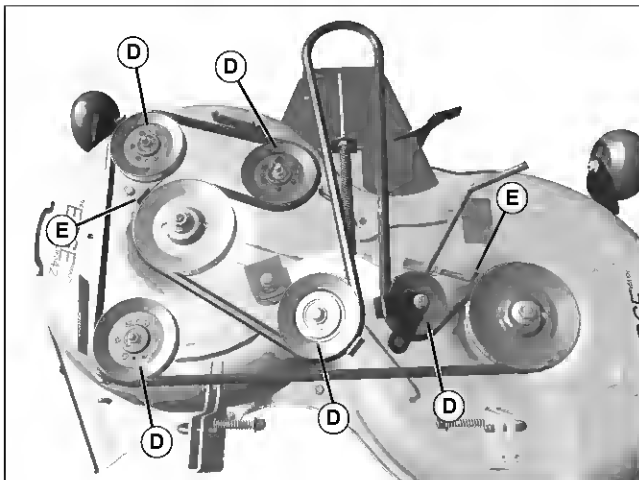
**SN -20000 shown**



MX39590

**SN 20001- shown**

- Remove one bolt (A) and slide belt shield (B) outward and off of two slotted holes (C) on top of mower deck.

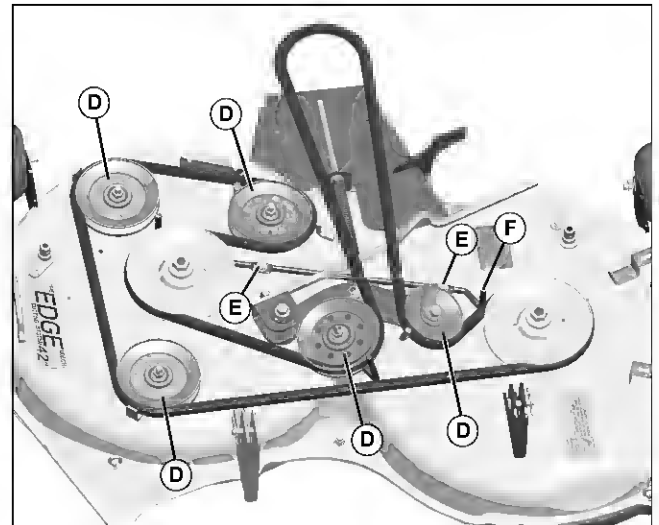


MX36299

**SN -20000 shown**

- Loosen hardware for five sheaves (D).

- Loosen hardware for belt guides (E).
- Remove mower belt.



MX39591

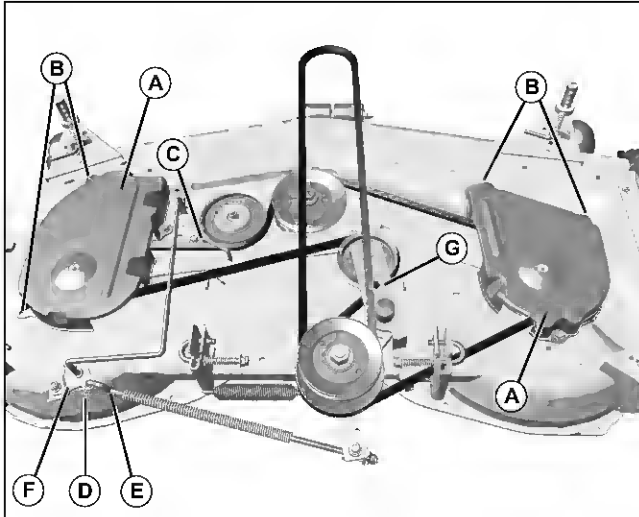
**SN 20001- shown**

- Loosen hardware for five sheaves (D).
  - Remove two bolts (E) and belt guide (F).
  - Remove mower belt.
5. Inspect belt for wear or damage; replace as necessary.
  6. Clean top surface of mower deck and sheaves.
  7. Install belt on mower deck as shown. Make sure belt is in the groove of each sheave, there is no twist in the belt, and the belt is inside belt guides.
  8. Tighten belt guides.
  9. Tighten sheave hardware to 54 N•m (40 lb-ft).
  10. Install belt shield, making sure shield is secured onto two slotted holes on top of mower deck. Secure with bolt.
  11. Install mower deck.

## ATTACHMENTS REPAIR

### Replacing Mower Drive Belt (Secondary) (48 and 54 in. Mowers)

1. Park machine safely. See "Parking Safely" in Safety section.
2. Allow engine and muffler to cool completely.
3. Remove mower deck.
4. Remove drive belt:



MX36275

#### 54-in. mower shown.

- Remove one bolt on each belt shield (A), and slide belt shields outward to remove tabs on belt shields from slotted holes (B) in mower deck.
- Remove bolt and belt guide (C).
- Remove small spring locking pin (D), and remove tension rod (E) from tension handle bracket (F).



**Caution: Avoid Injury! Tension arm is under spring tension. Use caution and wear gloves when removing belt.**

- To remove belt, rotate tension arm (G) slightly clockwise, and remove belt from sheaves.
5. Inspect belt for wear or damage; replace as necessary.
  6. Clean top surface of mower deck and sheaves.
  7. Install belt on mower deck as shown. Make sure belt is under tension rod (E), and in the groove of each sheave and inside belt guide (C), and if necessary, rotate tension arm (G) slightly to place belt onto the last sheave.
  8. Install and tighten belt guide (C).
  9. Install tension rod (E) onto tension handle bracket (F), and secure with small spring locking pin (D).
  10. Install belt shields onto slotted holes on mower deck and

slide each shield towards center of deck. Secure each shield with one cap screw.

11. Install mower deck.

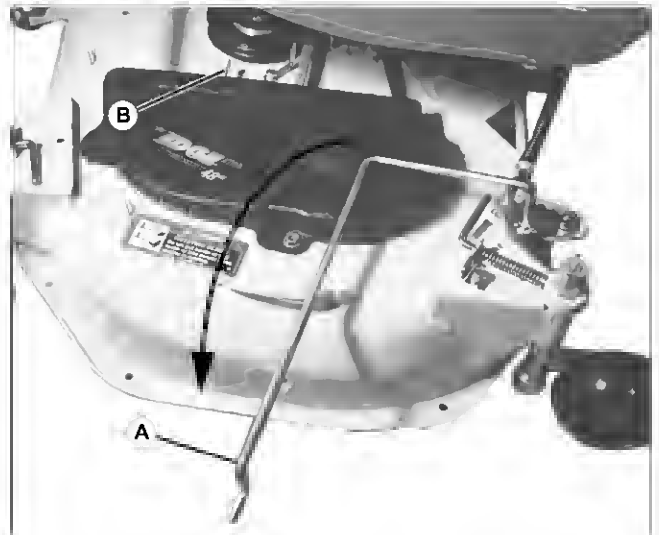
### Replacing Mower Drive Belt (Primary) (48 in. and 54 in. Mowers)

1. Park machine safely. See "Parking Safely" in Safety section.
2. Allow engine and muffler to cool completely.
3. Lock mower deck in lowered position.



**Caution: Avoid Injury! Belt tension rod is spring-assisted and under tension. Keep a secure grasp on rod at all times while releasing or applying drive belt tension.**

4. Remove drive belt tension:



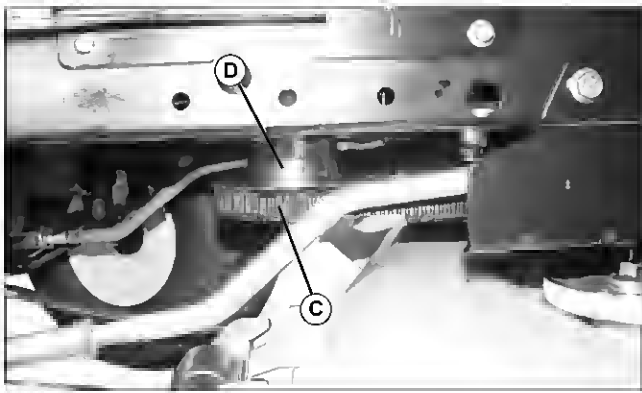
MX36286

**Picture Note: 48 in. mower shown. Lever on left side.**

- Grasp and hold tension rod (A) securely.
- Disengage rod from retaining bracket (B) by rotating rod counterclockwise.
- Move rod as far as possible toward rear wheel to remove all belt tension.



# ATTACHMENTS REPAIR

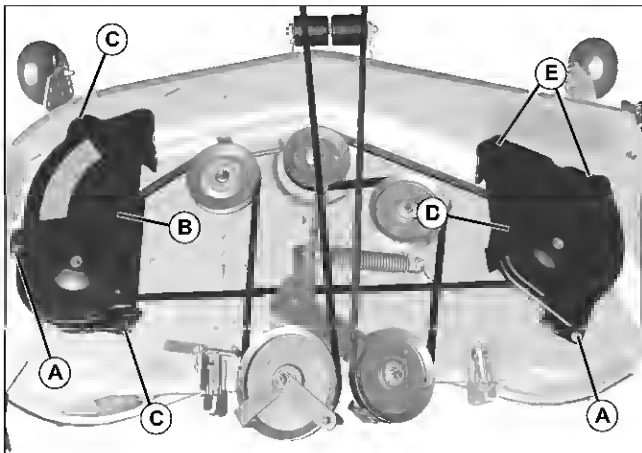


MX36287

5. Remove primary mower drive belt (C) from engine sheave (D), and move tension rod back into retaining bracket.
6. Clean belt with a clean cloth.
7. Inspect belt for wear or damage; replace as necessary.
8. Install belt on mower sheave and engine sheave.
9. Pivot drive belt tension rod toward front of machine to tighten drive belt. Hook tension rod into bracket on mower.

## Replacing Mower Drive Belt (48 Mower - Single Belt Drive)

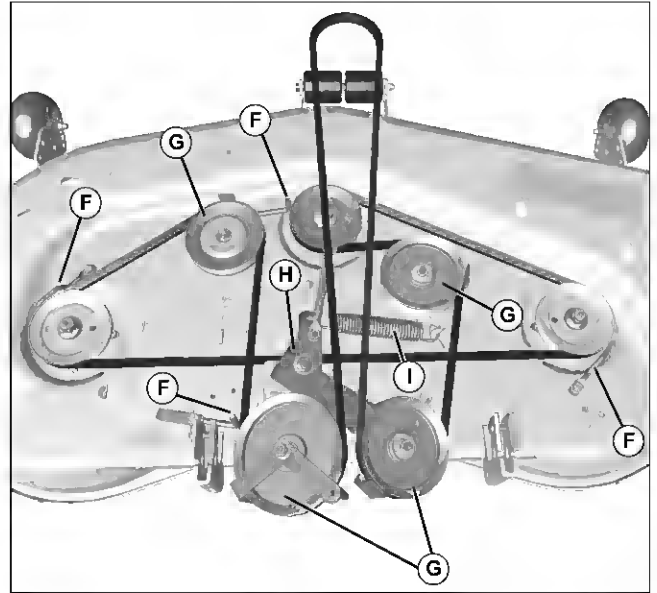
1. Park machine safely. See "Parking Safely" in the Safety section.
2. Allow engine and muffler to cool completely.
3. Remove mower deck.
4. Remove drive belt:



MX38000

- Remove one bolt (A) on left belt shield (B), and slide belt shield outward to remove tabs on belt shield from slotted holes (C) in mower deck.
- Remove one bolt (A) on right belt shield (D), and slide belt shield rearward to remove tabs on belt shield from slotted holes (E) in mower deck

**Note:** Be sure to make note of the exact location of independent belt guides, and belt guides on sheaves. The mower drive belt may prematurely wear or slip if belt guides are not installed correctly.



MX36286

- Loosen hardware for four belt guides (F).
  - Loosen hardware for four sheaves (G) to remove belt from sheave belt guides.
  - To remove belt, rotate tension arm (H) slightly counterclockwise, and remove belt from sheaves.
5. Inspect belt for wear or damage; replace as necessary.
  6. Clean top surface of mower deck and sheaves.
  7. Install belt on mower deck as shown. Make sure belt is in the groove of each sheave and inside belt guides (F), and if necessary, rotate tension arm (H) slightly to place belt onto the last sheave.
  8. Tighten nuts on sheaves (G) to specification.
  9. Install and tighten belt guides.
  10. Install belt shields onto slotted holes on mower deck and slide left shield towards center of deck and right shield forward. Secure each shield with one bolt.
  11. Before installing deck, make sure tension spring (I) is installed. Rotate tension arm (H) clockwise and install spring onto bottom square hole in tension arm.
  12. Install mower deck.

### Specification:

**Idler Sheave Nuts** . . . . . 47 N•m (35 lb-ft)

# ATTACHMENTS REPAIR

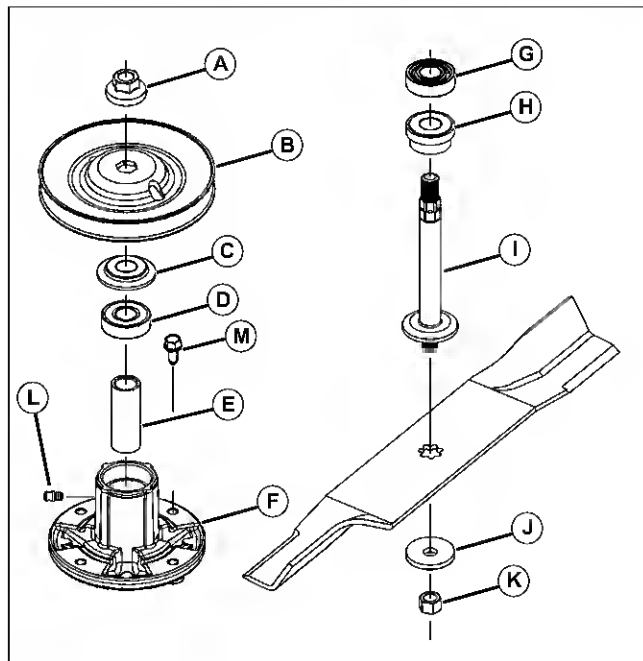
## Spindle - 38 and 42-Inch Decks

### Disassembly:



**Caution: Avoid Injury! Wear gloves or wrap blade with rag to prevent personal injury.**

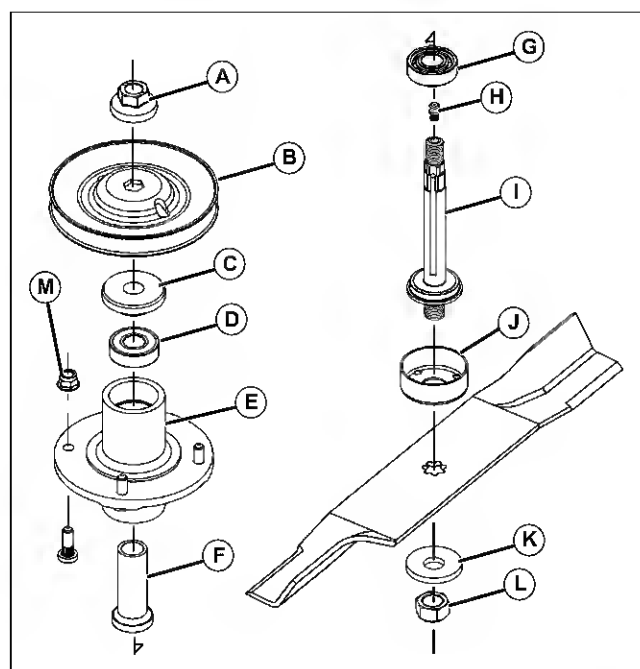
**Important: Avoid Damage! Do not install hexagon end of spindle shaft in a vise. The hexagon end of the spindle shaft may be damaged resulting in improper blade operation.**



MX37104

### Spindle to Model Year 2009 shown

- A- Spindle Sheave Nut
- B- spindle Sheave
- C- Seal Ring
- D- Bearing
- E- Spacer
- F- Spindle Housing
- G- Bearing
- H- Seal ring
- I- Spindle
- J- Washer
- K- Nut
- L- Lubrication Fitting
- M- Screws (4 used)



MX44232

### Spindle Starting Model Year 2010 shown

- A- Spindle Sheave Nut
- B- Spindle Sheave
- C- Seal Ring
- D- Bearing
- E- Spindle Housing
- F- Spacer
- G- Bearing
- H- Lubrication Fitting
- I- Spindle
- J- Deflector Cup
- K- Washer
- L- Nut
- M- Nuts (4 used)

1. If only the spindle sheave nut (A) and spindle sheave (B) need to be replaced, and the spindle is still in the deck, use a block of wood to prevent the blade from turning. Use an impact wrench to remove nut (A); or, tighten blade nut (K) to 108 N•m (80 lb-ft). Remove spindle nut and sheave.
2. To disassemble the spindle:
  - Use a block of wood to prevent the blade from turning and remove spindle sheave nut (A), spindle sheave (B), and lubrication fitting (L).
  - Remove blade nut, washer, and blade.
  - Remove four screws or nuts securing spindle housing to deck.
  - Pull spindle shaft and seal rings out of spindle housing.

# ATTACHMENTS REPAIR

**Note:** Remove bearings only if replacement is necessary.

- Bearings (D and G) are seated against spindle hub shoulder and cannot be removed with a press. Remove bearings using a punch.
- Remove spacer.

3. Inspect all parts for wear or damage. Replace parts as necessary.

## Assembly:

Installation is done in the reverse order of removal.

**Important: Avoid Damage! If bearing has an open side, the open side should orient to inside of spindle.**

- Press top bearing into spindle housing, install spacer, press second bearing into housing.
- Install seal ring(s) and spindle.
- Install blade. See "Mower Blade Removal and Installation" on page 539. While holding blade in a vise, tighten nut (K) to specification
- Position spindle housing into deck from the bottom, attach with mounting hardware. Tighten screws or nuts to specification.
- Place spindle sheave (B) onto end of spindle and secure with nut (A). While holding blade nut, tighten spindle nut to specification.
- Loosen blade nut and retighten to specification.

## Torque Specifications:

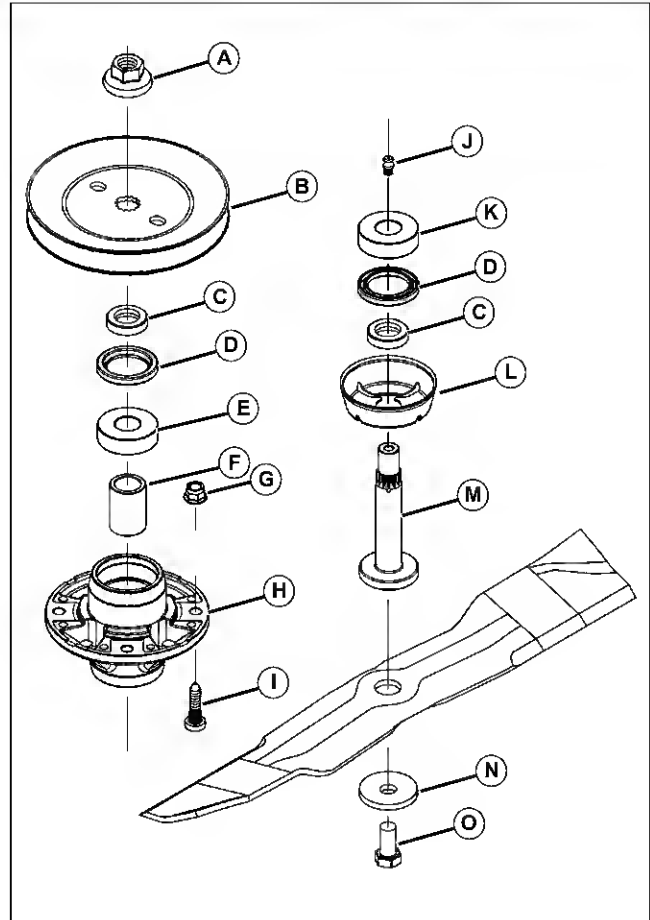
Spindle Sheave Nut .....	108 N•m (80 lb-ft)
Blade Nut (12 mm) .....	68 N•m (50 lb-ft)
Blade Nut (5/8 in.) .....	88 N•m (65 lb-ft)
Spindle Mounting Hardware .....	30 N•m (22 lb-ft)

## Spindle - 48 and 54-Inch Decks

### Disassembly:



**Caution: Avoid Injury! Wear gloves or wrap blade with rag to prevent personal injury.**



MX37105

- A- Spindle sheave nut
- B- spindle sheave
- C- Thrust Washer (2 used)
- D- Seal (2 used)
- E- Spacer
- F- Bearing
- G- Nut (4 used)
- H- Spindle Housing
- I- Screws (4 used)
- J- Lubrication Fitting
- K- Bearing
- L- Deflector
- M- Spindle
- N- Washer
- O- Bolt

# ATTACHMENTS REPAIR

1. If only the spindle sheave nut (A) and spindle sheave (B) need to be replaced, and the spindle is still in the deck, use a block of wood to prevent the blade from turning. Use an impact wrench to remove nut (A); or, tighten blade bolt (K) to 108 N•m (80 lb-ft). Remove spindle nut and sheave.

2. To disassemble the spindle:

- Use a block of wood to prevent the blade from turning and remove spindle sheave nut (A), spindle sheave (B)
- Pull spindle shaft (I) out of spindle housing.
- Secure the blade in a vise and remove bolt (O), washer (N), blade, and deflector (L).

**Important: Avoid Damage! Note lubrication grooves in thrust washers face toward blade.**

- Remove thrust washers (C).
- Remove four nuts (G) securing spindle housing to deck. Remove spindle housing.

**Important: Avoid Damage! Seal lips face toward ends of spindle. Install new seals when assembling.**

- Remove seals (D) from spindle housing.

**Note: Remove bearings only if replacement is necessary.**

- Bearings (D and K) are seated against spindle hub shoulder and cannot be removed with a press. Remove bearings using a punch.
- Remove spacer (F).

3. Inspect all parts for wear or damage. Replace parts as necessary.

## Assembly:

Installation is done in the reverse order of removal.

- Press either bearing into spindle housing, install spacer (E), press second bearing into housing.

**Important: Avoid Damage! Note direction of seal lips are toward ends of spindle and thrust washer lubrication grooves are both toward blade end of spindle.**

- Install seals and thrust washers.
- Position spindle housing (H) into deck from the bottom, attach with four nuts (G). Tighten nuts to **27 N•m (20 lb-ft)**.
- Install blade. See "Mower Blade Removal and Installation" on page 539. While holding blade in a vise, tighten bolt (O) to 108 N•m (80 lb-ft).
- Install deflector (L) and then spindle assembly into spindle housing.

- Place spindle sheave (B) onto end of spindle and secure with nut (A). While holding blade nut, tighten spindle nut to specification.
- Loosen blade nut and retighten to specification.

## Torque Specifications:

**Spindle Sheave Nut . . . . . 142 N•m (105 lb-ft)**

**Blade Nut (48-Inch & 54-Inch Decks) . . 68 N•m (50 lb-ft)**

**Spindle Mounting Cap Screw . . . . . 30 N•m (22 lb-ft)**

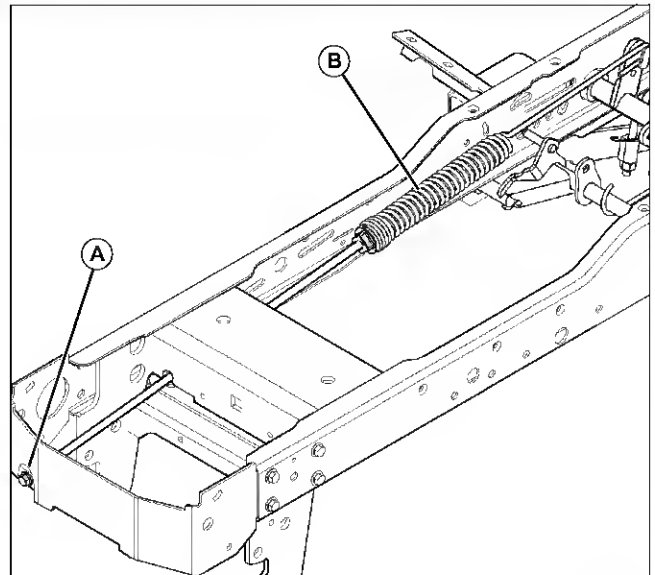
## Manual Lift Linkage Removal and Installation

### Disassembly:

1. Remove mower deck.



**Caution: Avoid Injury! Springs may be under tension. Unexpected movement can cause injury. Wear gloves and eye protection. Before working on any part of the lift mechanism, release all tension from the lift assist spring.**



MX37107

2. Unscrew lift assist spring bolt (A) to release all tension on assist spring (B). Release deck lift pedal to highest position.

# ATTACHMENTS REPAIR

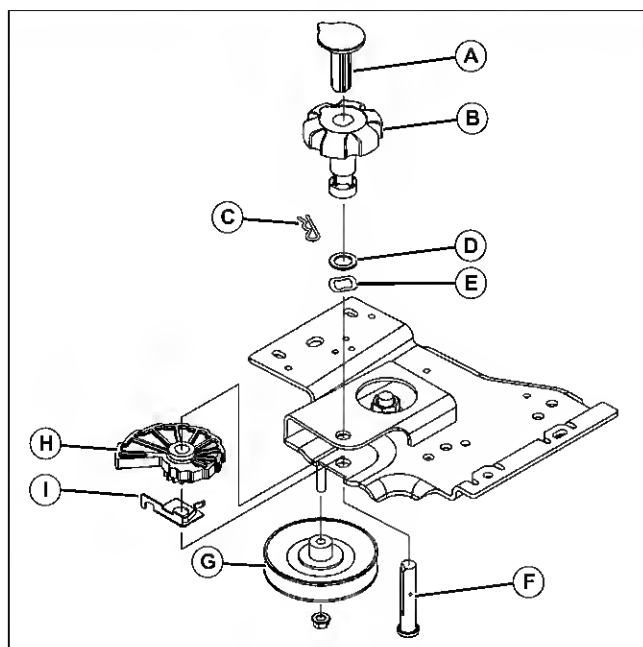
## Height Adjuster:

1. Lock park brake to relief tension on drive belt.
2. Remove mower deck.
3. Raise hood. Disconnect negative (-) battery cable.
4. Remove fender deck. See "Fenderdeck Removal and Installation" on page 566 in the Miscellaneous section.



**Caution: Avoid Injury! Springs may be under tension. Unexpected movement can cause injury. Before working on any part of the lift mechanism, release all tension from the lift assist spring.**

5. Unscrew lift assist spring bolt to release all tension on assist spring. Set deck lift to highest position.



MX37108

6. Remove center plug (A) and knob (B).
7. Remove spring pin (C), washer (D) and wave washer (E).

**Important: Avoid Damage! Drive belt idler (G) may need to be removed for clearance before removing pin (F).**

8. Remove pin (F) from plate assembly.
9. Remove depth stop cam (H) and spring clip (I).

Assembly is done in reverse order of removal.

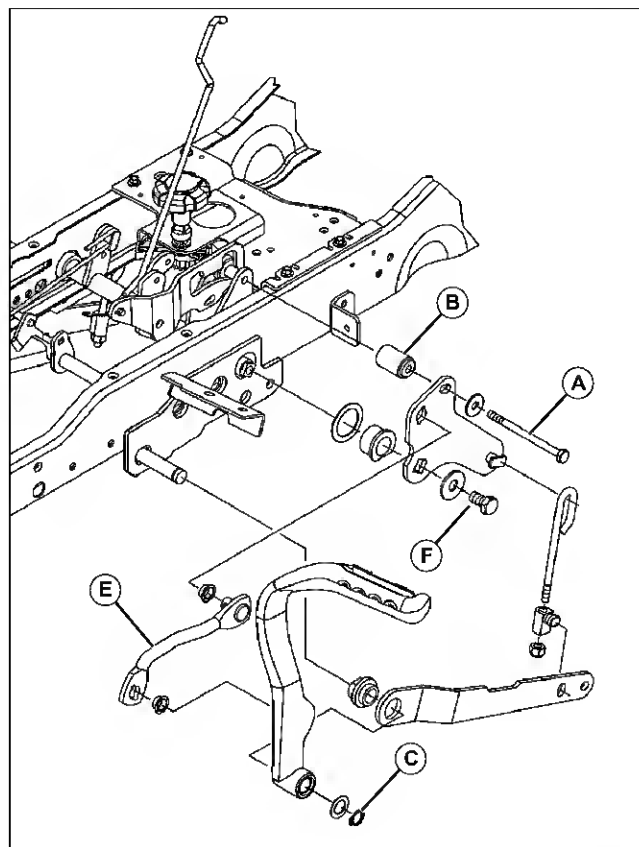
## Lift Pedal Removal:

1. Lock park brake to relief tension on drive belt.
2. Remove mower deck.



**Caution: Avoid Injury! Springs may be under tension. Unexpected movement can cause injury. Before working on any part of the lift mechanism, release all tension from the lift assist spring.**

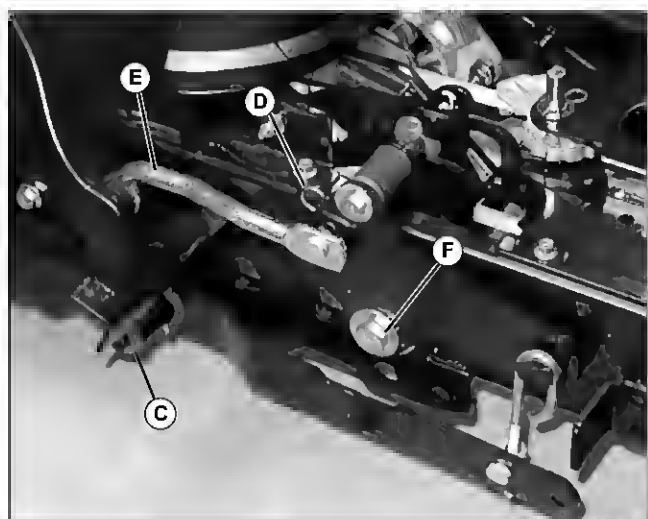
3. Unscrew lift assist spring bolt to release all tension on assist spring. Set deck lift to highest position.
4. Raise hood. Disconnect negative (-) battery cable.
5. Remove fender deck. See "Fenderdeck Removal and Installation" on page 566 in the Miscellaneous section.



MX37110

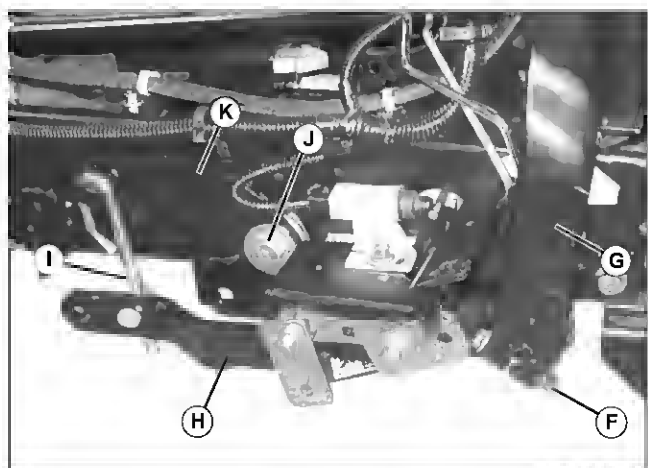
6. Remove bolt (A), washer, and spacer (B).

# ATTACHMENTS REPAIR



MX36342

7. Remove snap ring (C) and washer securing lift pedal to brake shaft.
8. Remove hair pin (D) securing lift link to pivot plate.
9. Remove lift pedal and rotate as necessary to remove link (E).
10. Remove bolt (F) and washer securing pivot plate to lift shaft assembly.
11. Inspect all bushing for wear. Replace as necessary.



MX36339

12. Remove the brake pedal clamp bolt (F) and the brake pedal (G).
13. Remove the draft arm (H) and lift link (I).
14. Remove cap screw (J), lift arm (K), washer and bushing.
15. Remove lift shaft assembly.

## Assembly:

Assembly is done in reverse order of removal.

- Models with two brake pedal clamp bolts: The top brake pedal mounting bolt should be tightened before the bottom

mounting bolt.

## Specifications:

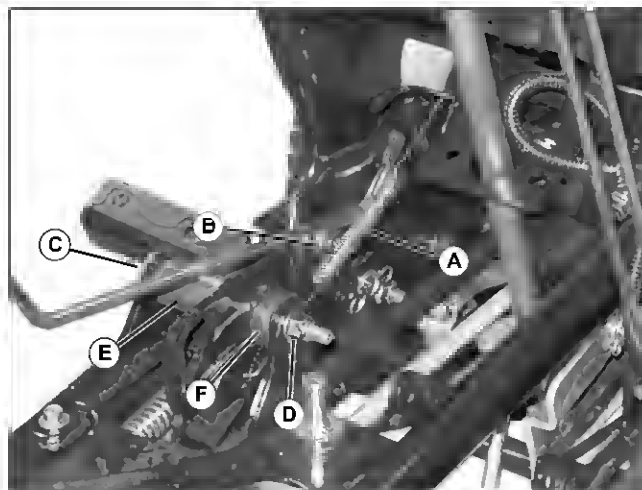
**Draft Arm Retaining Cap Screw . . . . 230 N•m (170 lb-ft)**  
**Brake Pedal Mounting Bolts . . . . . 60 N•m (80 lb-ft)**

## Lift Lock Handle:

1. Park machine safely with park brake locked. See "Parking Safely" in the Safety section.
2. Remove mower deck. See Mower Deck Removal and Installation for the appropriate deck in the Attachments section.
3. Raise hood and disconnect negative (-) battery cable.
4. Remove fender deck. See "Fenderdeck Removal and Installation" on page 566 in the Miscellaneous section.
5. Remove the control panel. See "Control Panel Removal and Installation" on page 563 in the Miscellaneous section.



**Caution: Avoid Injury! Lift lock extension spring-is under tension.**



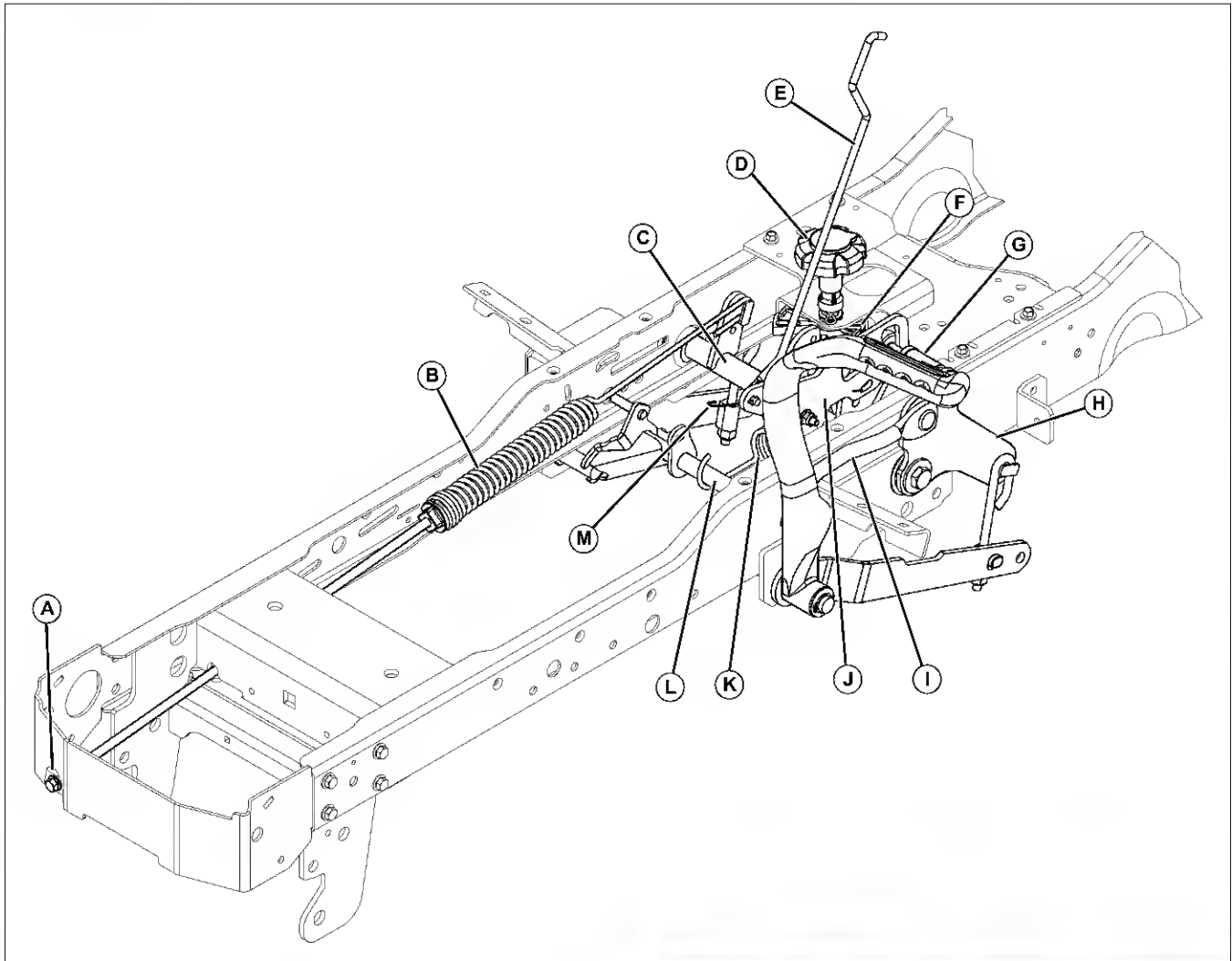
MX36343

6. Remove bolt (C), nut (D), spacer (E), and bushing (F).
7. Remove the lift lock extension spring (A) and the lift lock pivot bolt (B).
8. Remove linkage assembly.

Assembly is done in reverse order of removal.

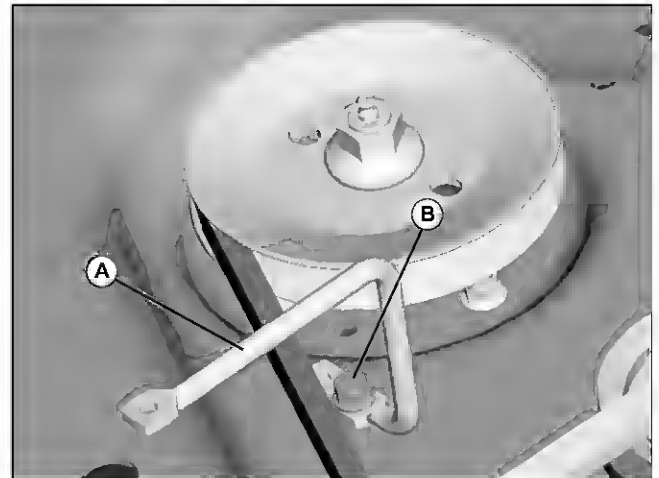
# ATTACHMENTS REPAIR

## Deck Lift Assembly:



MX37106

- A- Assist Spring Adjustment Screw
- B- Rockshaft, Lift Pivot Shaft
- C- Lift Assist Spring (48 and 54 Inch Decks)
- D- Deck Cutting Height Adjustment Knob
- E- Deck Lift Lock Rod
- F- Depth Stop Cam
- G- Spacer
- H- Pivot Plate, LH
- I- Link Rod
- J- Latch Pivot Arm
- K- Brake Spring
- L- Brake Pedal Shaft
- M- Latch Extension Spring



MX46854

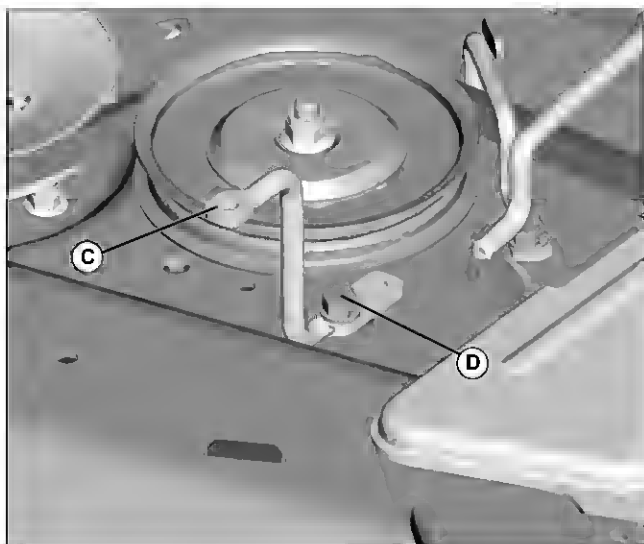
## Install Mower Deck Shields

### Install Shield Mounting Brackets

1. Remove right shield.

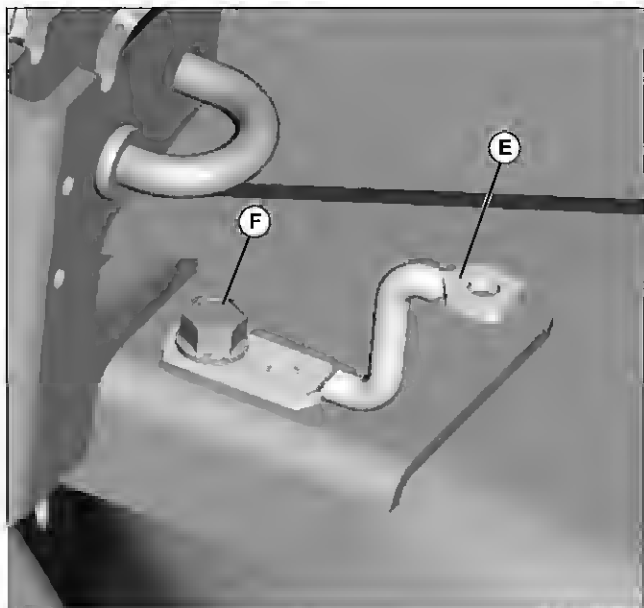
2. Install right shield bracket (A) using M8 self-tapping screw (B). Install right shield after installing bracket.

## ATTACHMENTS REPAIR



MX46855

3. Install left shield bracket (C) using M8 self-tapping screw (D).

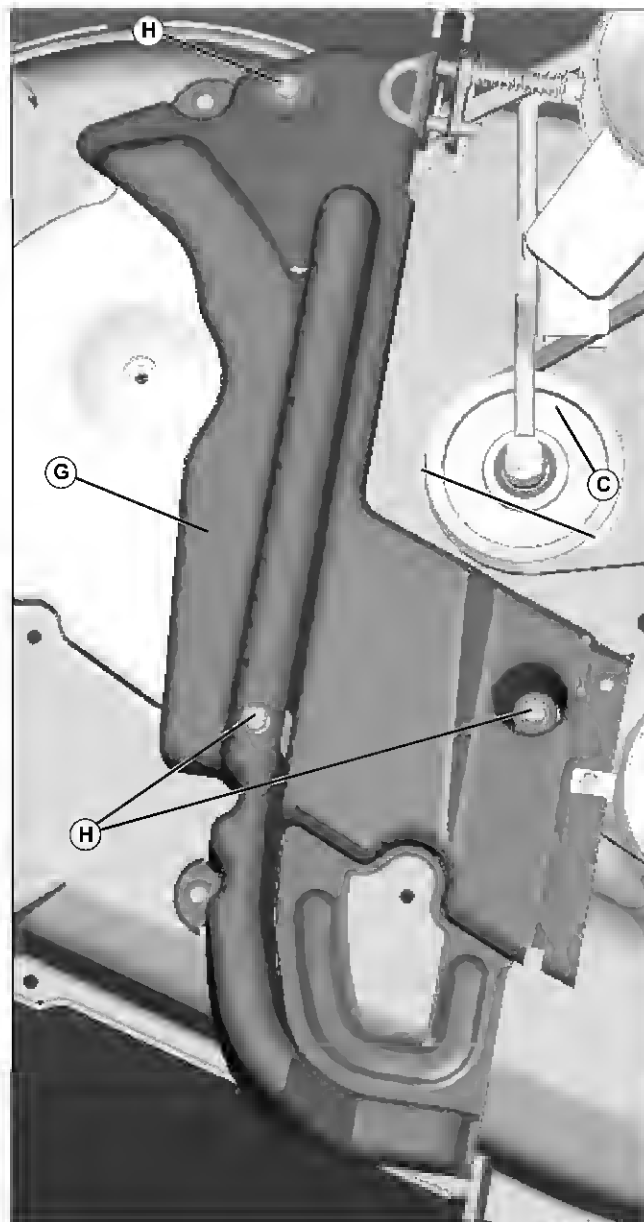


MX46856

4. Install rear shield bracket (E) using M8 self-tapping screw (F).

### Install Left and Right Deck Shields

1. Install the mower deck on the machine. Refer to mower deck operator's manual for procedure.

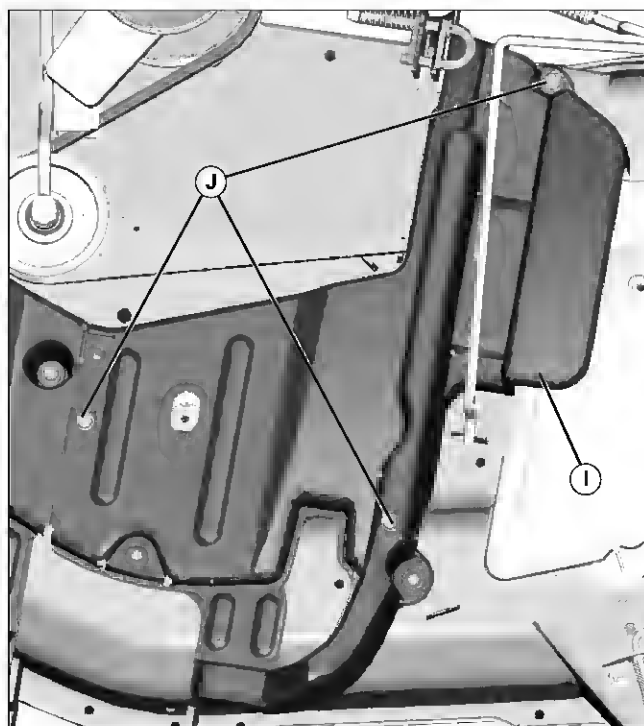


MX46857

2. Install the new right shield (G) with three M8 self-tapping screws (H) provided in kit.



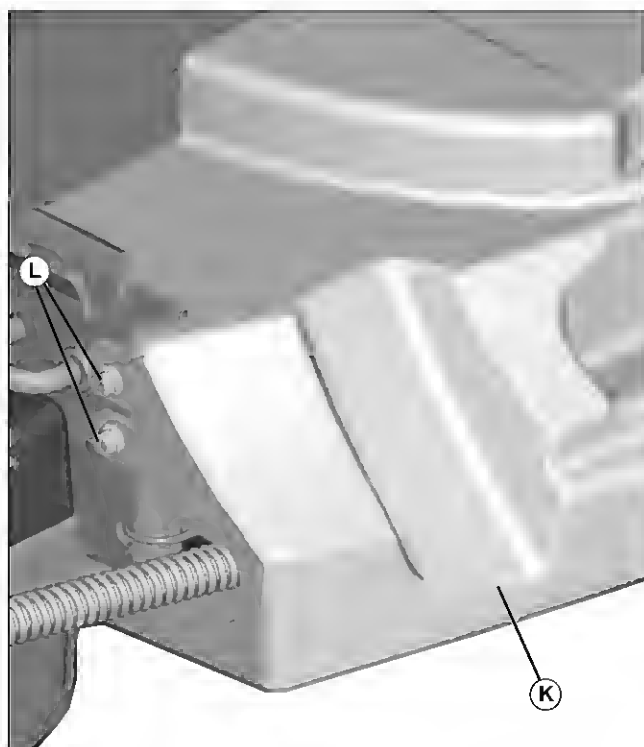
## ATTACHMENTS REPAIR



MX46858

3. Install the new left shield (I) with three M8 self-tapping screws (J) provided in kit.

### Install Rear Shield

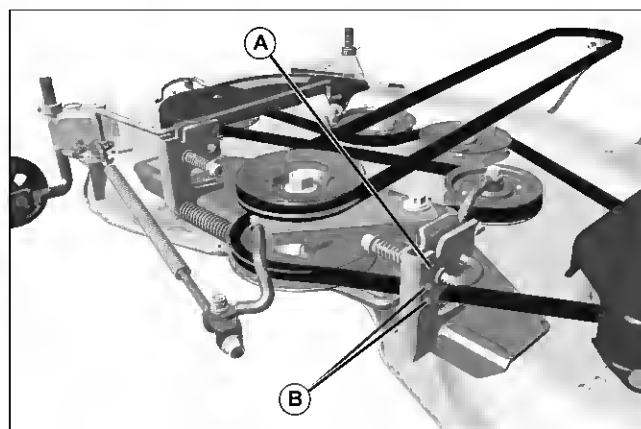


MX46859

1. Install the rear shield (K) with four M6 self-tapping screws (L) provided in kit.

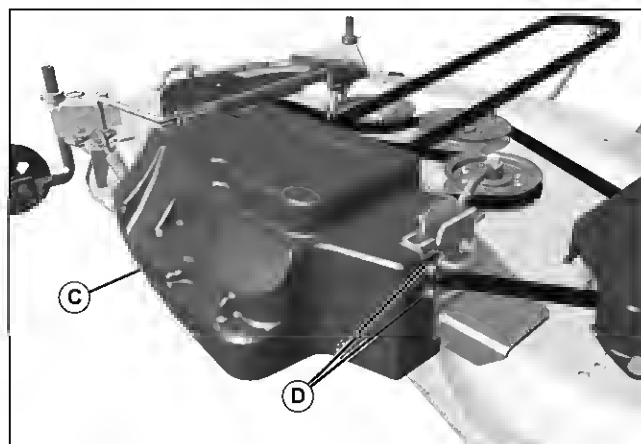
### Install Rear Deck Shield

**NOTE:** A template located in the rear of this document is required for the following step. Cut out template "1" before proceeding.



MX41403

1. Place template "1" on the outer face of the right lift tower (A) on the rear of the deck. Align the template to the edges of the lift tower, and mark two holes (B).
2. Remove the template and drill two 5.5 mm (7/32 in.) holes in the marked locations.
3. Place the template on the outer face of the left lift tower. Align the template to the edges of the lift tower, and mark two holes on the tower.



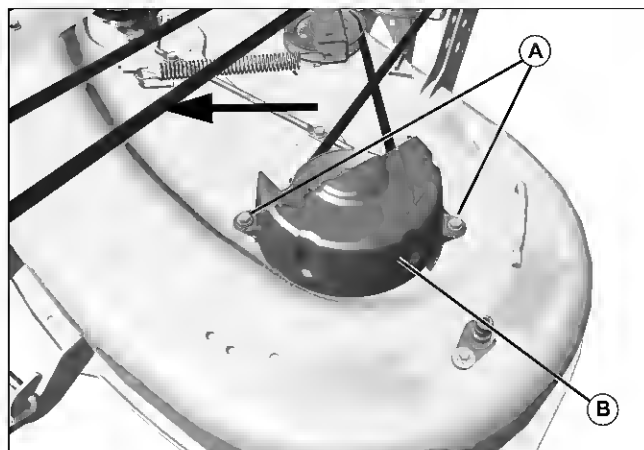
MX41404

4. Remove templates and place rear shield on deck as shown (C). Verify the hole locations marked with the holes in the shield. Adjust hole markings if necessary
5. Remove the shield and drill four 5.5 mm (7/32 in.) holes in the marked locations.
6. Install rear shield (C) with four M6 self-tapping screws, using two (D) on each side.

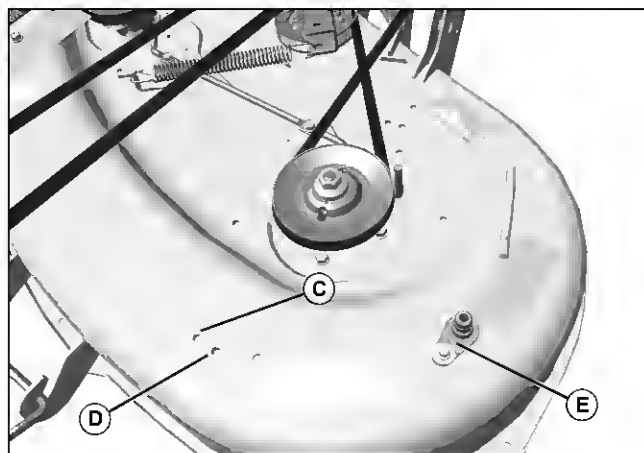
# ATTACHMENTS REPAIR

## Install Deck Side Shields

### Left Deck Preparation



1. Remove two screws (A) and existing belt shield (B) from mower deck. Retain the screws for later use.



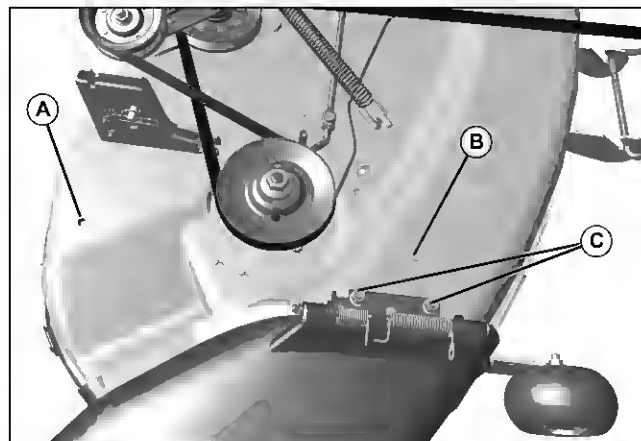
2. Check the mower deck for an existing hole (C).

**NOTE:** Some mower decks will have this hole, required for installation of the new shield. If your deck has the hole indicated above, proceed to Right Deck Preparation.

**If your deck does not have the hole indicated above, a template located at the end of this document is required for the following step. Cut out template "C" before proceeding to the next step.**

3. Place template "C" on the left front side of the deck. Align the template to the existing hole (D), and wash port (E), and mark the hole (C) required.
4. Remove the template and drill one 7.3 mm (9/32 in.) holes at the marked location.

### Right Deck Preparation



1. Check the mower deck for two existing holes (A, B) in the locations indicated above.

**NOTE:** Some mower decks will have the holes required for installation of the new shield. If your deck has the holes indicated above, proceed to Install Left and Right Deck Shields.

**If your deck does not have the holes indicated above, a template located in the rear of this document is required for the following step. Cut out template "D" before proceeding to the next step.**

2. Remove the two screws (C) securing the grass deflector shield to the deck. Remove the deflector shield.
3. Place template "D" on the right side of the deck. Align the template to the deflector shield mounting holes (C) and mark one hole on the mower deck.
4. Remove the template and temporarily place the shield on the deck, aligning it with the hole just marked and the right lift tower. Using the shield as a template, mark the second hole in the deck.

**NOTE:** Be sure right shield does not touch belt or spindle sheave before drilling two holes. Adjust hole markings as necessary.

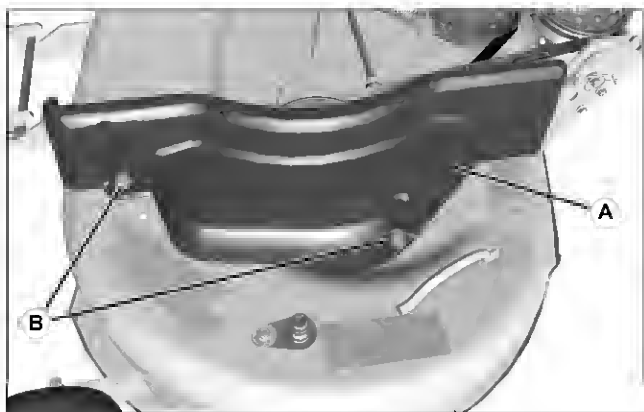
5. Drill two 7.3 mm (9/32 in.) holes at the marked locations.
6. Install grass deflector shield removed earlier.

### Install Left and Right Deck Shields

1. Install the mower deck on the machine. Refer to mower deck operator's manual for procedure.

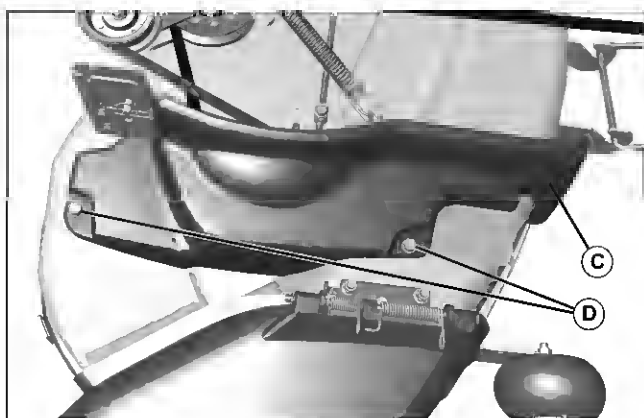
## ATTACHMENTS REPAIR

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MX41400

2. Install the new left shield (A) with two M8 self-tapping screws (B) removed earlier.



MX41402

3. Install the new right shield (C) with two M8 self-tapping screws (D).

## ATTACHMENTS REPAIR

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# MISCELLANEOUS TABLE OF CONTENTS

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MISCELLANEOUS TABLE OF CONTENTS

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# MISCELLANEOUS SPECIFICATIONS

## Specifications

### General Specifications

#### Models X300

Size (Front) .....	15 x 6.00 - 6
Size (Rear) .....	20 x 10.0 - 8
Tire Pressure (Front) .....	97 kPa (14 psi)
Tire Pressure (Rear) .....	69 kPa (10 psi)

#### Model X304 and X324

Size (Front) .....	15 x 6.00 - 6
Size (Rear) .....	20 x 10.00 - 10
Tire Pressure (Front) .....	97 kPa (14 psi)
Tire Pressure (Rear) .....	69 kPa (10 psi)

#### Models X320, X340 and X360

Size (Front) .....	15 x 6.5 - 8
Size (Rear) .....	22 x 11.00 - 10
Tire Pressure (Front) .....	97 kPa (14 psi)
Tire Pressure (Rear) .....	69 kPa (10 psi)

#### Capacities

Fuel (SN -0150000) .....	13.2 L (3.5 gal)
Fuel (SN 0150001-) .....	12.5 L (3.3 gal)

### Torque Specifications

#### Specifications:

Steering Wheel Nut. ....	39 - 49 N•m (29 - 36 lb-ft)
Wheel Bolts .....	88 N•m (65 lb-ft)

### Other Materials

#### Other Material

Part No.	Part Name	Part Use
TY25083 / Canada CXTY25083	EP High Temperature Grease	Lubricate spindles
PM37418 LOCTITE 242	Thread Lock and Sealer (Medium Strength)	Apply to threads of sheave set screws

Loctite is a registered trademark of the Loctite Corp.

# MISCELLANEOUS TESTS AND ADJUSTMENTS

## Tests and Adjustments

### Tire Pressure Adjustment



**Caution: Avoid Injury! Explosive separation of a tire and rim parts can cause serious injury or death:**

- Do not attempt to mount a tire without the proper equipment and experience to perform the job.
- Always maintain the correct tire pressure. Do not inflate the tires above the recommended pressure. Never weld or heat a wheel and tire assembly. The heat can cause an increase in air pressure resulting in a tire explosion. Welding can structurally weaken or deform the wheel.
- When inflating tires, use a clip-on chuck and extension hose long enough to allow you to stand to one side and NOT in front of or over the tire assembly.
- Check tires for low pressure or cuts.

#### Procedure:

1. Check tire and rim for damage.
2. Using an air pressure gauge, check air pressure.
3. Add or remove air as needed.

#### Specifications:

##### Models X300

Size (Front) .....	15 x 6.00 - 6
Tire Pressure (Front) .....	97 kPa (14 psi)
Size (Rear) .....	20 x 10.0 - 8
Tire Pressure (Rear) .....	69 kPa (10 psi)

##### Model X302 and X324

Size (Front) .....	15 x 6.00 - 6
Tire Pressure (Front) .....	97 kPa (14 psi)
Size (Rear) .....	20 x 10.00 - 10
Tire Pressure (Rear) .....	69 kPa (10 psi)

##### Models X320, X340 and X360

Size (Front) .....	15 x 6.5 - 8
Tire Pressure (Front) .....	97 kPa (14 psi)
Size (Rear) .....	22 x 11.00 - 10
Tire Pressure (Rear) .....	69 kPa (10 psi)

### Lift Assist Spring Adjustment

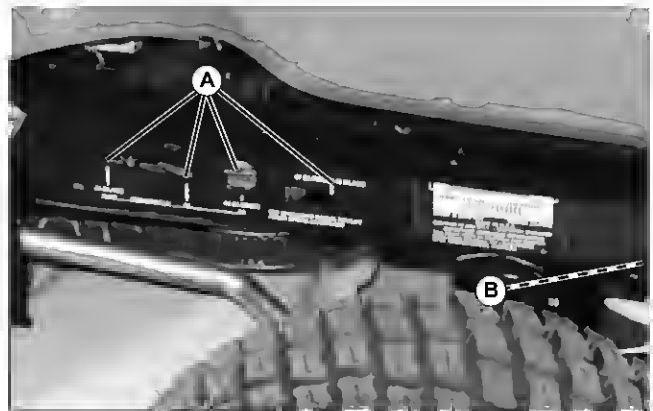
Lift assist spring is not standard on or applicable to all models. Refer to this section if equipped.

#### Purpose:

The weight of the mower deck affects ease of lifting. Adjust lift assist spring tension when installing a different deck to machine.

#### Procedure:

**Note: The weight of the mower affects ease of lifting. Adjust the lift assist spring for your particular mower deck model. The slotted opening has indicator marks for different size decks.**



MX36333

1. Make sure yellow indicator is aligned with the proper mark (A) for the mower deck installed. If not, adjust the lift assist spring so the indicator is aligned with the correct mower deck mark.
2. Turn adjusting bolt (B) at front of machine frame to adjust lift assist spring:
  - Clockwise - Increases spring tension and moves indicator toward front of machine for heavier mowers.
  - Counterclockwise - Decreases spring tension and moves indicator toward rear of machine for lighter mowers.



## MISCELLANEOUS REPAIR

### Repair

#### Front Wheel Removal and Installation

##### Removal:

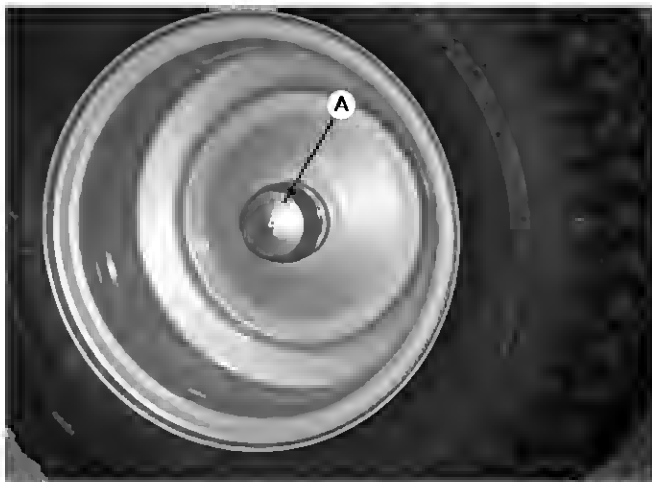
1. Park machine safely with park brake locked. See "Parking Safely" in the Safety section.



**Caution: Avoid Injury! The machine may fall or slip from an unsafe lifting device:**

- Use a device rated for the load to be lifted.
- Secure the machine properly to the lift.

2. Safely lift and support machine.



M89737

3. Remove plastic cap (A) from end of wheel hub.



M89736

4. Remove snap ring (B) from end of axle.
5. Remove washer (C), wheel, and shim washers, if present, from axle.

6. Inspect wheel bearings. Replace if necessary. See "Wheel Bearing Inspection/Replacement" procedure below.

##### Wheel Bearing Inspection/Replacement:

**Note: Remove bearings only if replacement is necessary.**

Inspect bearings for wear or damage. Replace if necessary.



M82927

- Remove either bearing (A) using a slide hammer and inside puller.
- Remove bearing on opposite end using a driver set and a press.
- Install bearings Using a press or bearing driver set that only pushes on outside rim of ball bearing. Do not drive ball bearings on by striking or pushing on inner race.

**Note: Do not drive ball bearings on by striking or pushing on inner race**

- Prior to installing bearing coat outer race, inner race and axle with a light layer of multipurpose grease.

##### Installation:

Installation is done in the reverse order of removal.

- Install wheels with valve stems facing away from machine.

## MISCELLANEOUS REPAIR

### Rear Wheel Removal and Installation - X300, X320, X340 and X360

#### Removal:

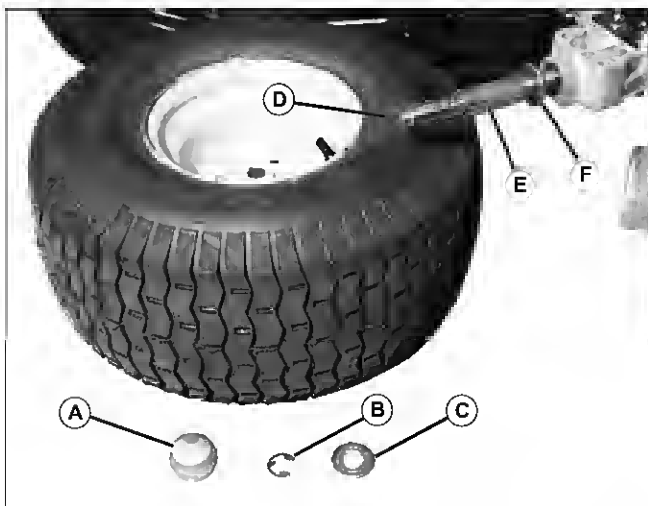
1. Park machine safely with park brake locked. See "Parking Safely" in the Safety section.



**Caution: Avoid Injury! The machine may fall or slip from an unsafe lifting device:**

- Use a device rated for the load to be lifted.
- Secure the machine properly to the lift.

2. Lift machine high enough to remove weight from wheels. Place jackstands under machine frame.



MX9664

3. Remove plastic cap (A), snap ring (B), and washer (C).
4. Remove wheel.
5. Remove key (D) (shown on end of transaxle shaft), spacer (E) and back washer (F).

#### Installation:

**Note: Rear wheels are installed with valves to the outside.**

1. Install back washer (F), spacer (E), and key (D).
2. Install rear wheel, washer (C), snap ring (B) and plastic cap (A).

### Rear Wheels Removal and Installation - X304 and X324

#### Removal:

1. Park machine safely with park brake locked. See "Parking Safely" in the Safety section.



**Caution: Avoid Injury! The machine may fall or slip from an unsafe lifting device:**

- Use a device rated for the load to be lifted.
- Secure the machine properly to the lift.

2. Lift machine high enough to remove weight from wheels. Place jackstands under machine frame.



M82928

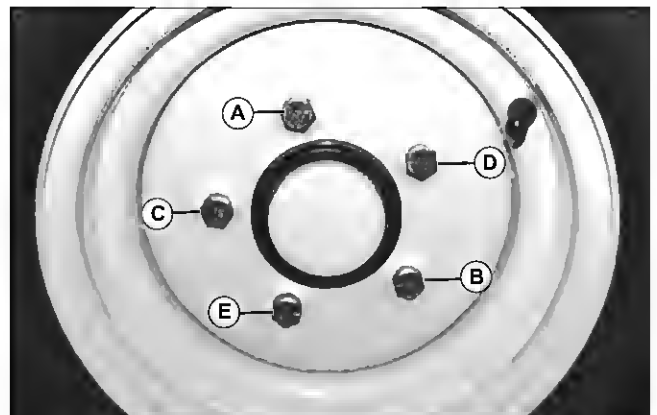
3. Remove five cap screws (A) and rear wheel assembly.

#### Installation:

Installation is done in the reverse order of removal.

**Note: Check wheel bolt torque often during the first 100 hours of operation.**

- Install wheels with valve stems facing away from machine.



M99521

## MISCELLANEOUS REPAIR

- Tighten rear wheel bolts evenly in proper sequence (A), (B), (C), (D), and (E) until snug.
- Tighten bolts to **specification**.

### Specification:

Wheel Bolts ..... 88 N•m (65 lb-ft)

## Hood Removal and Installation

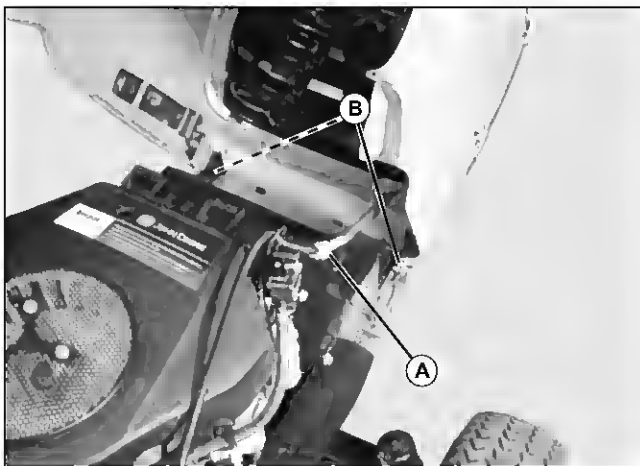
### Removal:

1. Park machine safely with park brake locked. See "Parking Safely" in the Safety section.



**Caution: Avoid Injury! Touching hot surfaces can burn skin. The engine and components will be hot if the engine has been running. Allow the engine to cool before removing hood.**

2. Let engine cool.
3. Pivot hood to open position.



MX36328

4. Disconnect wiring harness (A).
5. Lower hood slightly and lift hood from brackets (B).
6. Lift up and forward to remove hood from machine frame.

### Installation:

1. Bringing hood to frame at approximately a 45° angle, place hood into position, lining up hood pins with slots in hood mounting bracket. Open hood completely to fully seat pins in hood mounting bracket.
2. Connect electrical connector (A) for headlight wiring harness.
3. Close hood.

## Steering Wheel Removal and Installation

### Removal:

1. Use flat blade screw driver in seam between center cover and steering wheel. Remove steering wheel center cover.
2. Remove lock nut.
3. Remove steering wheel. If necessary, use a suitable puller.

### Installation:

**Note: Lubricate the steering shaft splines with general purpose grease before installing steering wheel to allow easy removal.**

1. Install steering wheel and retain with nut. Tighten steering wheel nut to specification.
2. Install center cover to steering wheel.

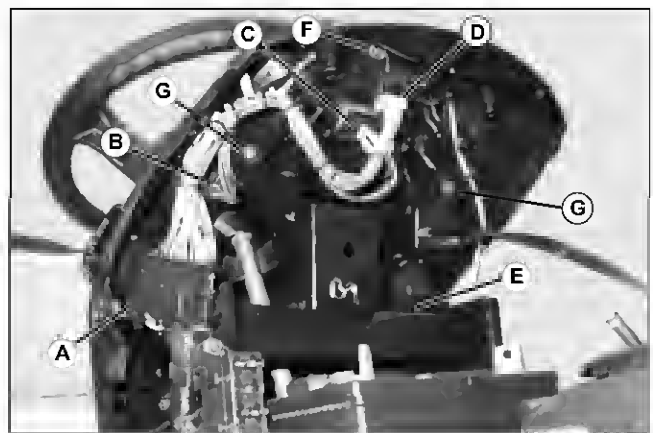
### Specification:

Steering Wheel Nut ..... 39 - 49 N•m (29 - 36 lb-ft)

## Control Panel Removal and Installation

### Removal:

1. Park machine safely with park brake locked. See "Parking Safely" in the Safety section.
2. Raise the hood.
3. Disconnect battery negative cable.

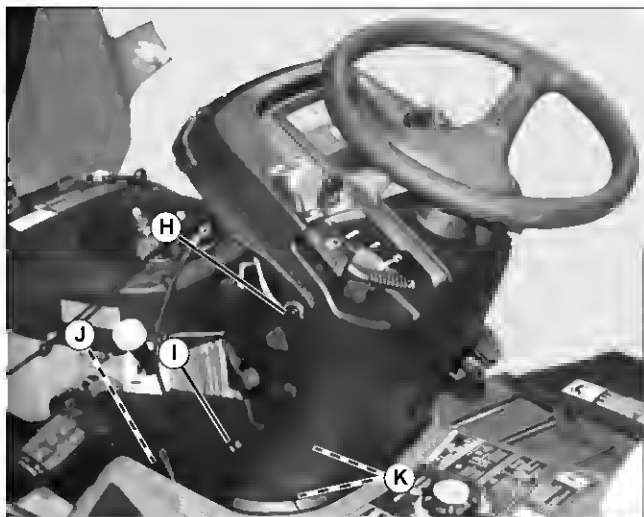


MX36334

4. Disconnect wiring connectors (A - E).
  - (A) - PTO/RIO Switch Connector
  - (B) - Key Switch Connector
  - (C) - Hour Meter Connector
  - (D) - Interlock Module Connector
  - (E) - Headlight Switch Connector (SN -040000)

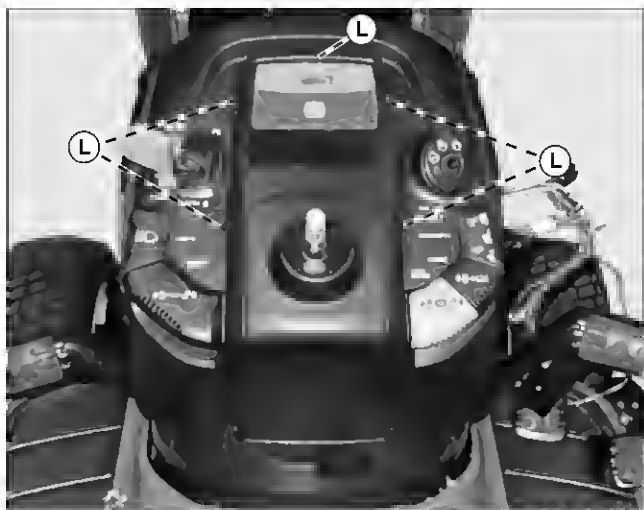
## MISCELLANEOUS REPAIR

5. Remove cap screw (F) and interlock module.
6. Remove two cap screws (G) securing upper control panel to the steering pedestal.



MX36335

7. Remove steering wheel. See "Steering Wheel Removal and Installation" on page 563.
8. Remove the hood latch (H) on each side of control panel.
9. Remove the cap screw (I) on each side of control panel.
10. Unlock the front (J) end of the close out panel from the frame. Carefully flex the panel to unlock the rear tabs (K).



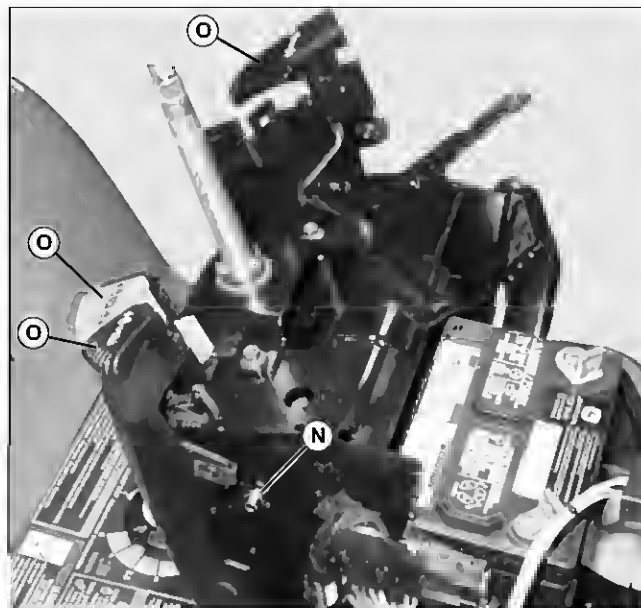
MX36336

11. Carefully flex the center panel inward to unlock the tabs (L) while lifting the center panel upward to remove.



MX36337

12. Unlock the tab (M). Lift the top control panel up and off of the steering pedestal.



MX36338

13. Loosen the two cap screws (N) on each side of steering pedestal.
14. Lift the three linkage levers (O). Tip the lower panel back and off of machine.

### Installation:

Installation is done in the reverse order of removal.

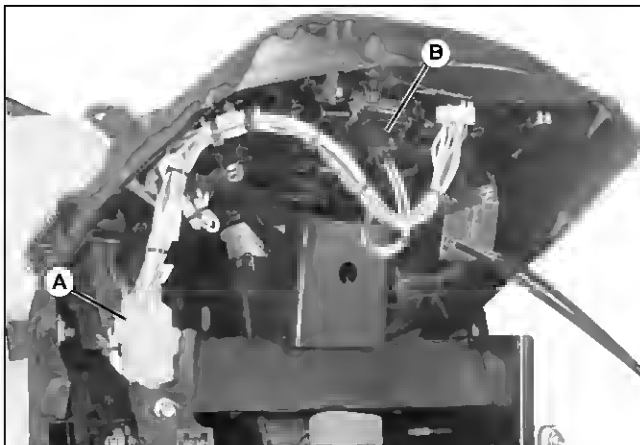
- Tighten steering wheel nut to **39 - 49 N•m (29 - 36 lb-ft)**.

## MISCELLANEOUS REPAIR

### Control Panel Removal and Installation (X360)

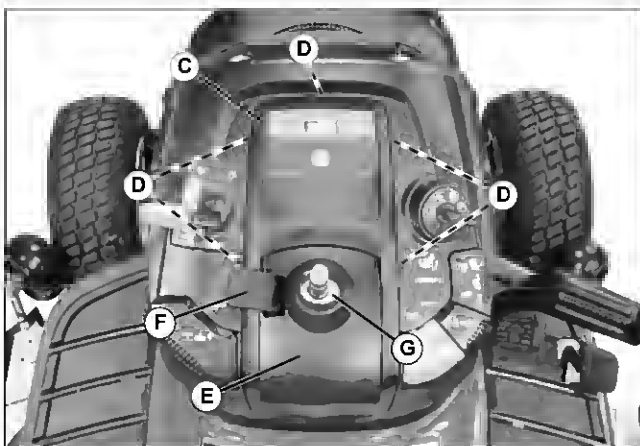
#### Removal:

1. Park machine safely with park brake locked. See "Parking Safely" in the Safety section.
2. Raise the hood.
3. Disconnect battery negative cable.
4. Remove steering wheel. See "Steering Wheel Removal and Installation" on page 563.



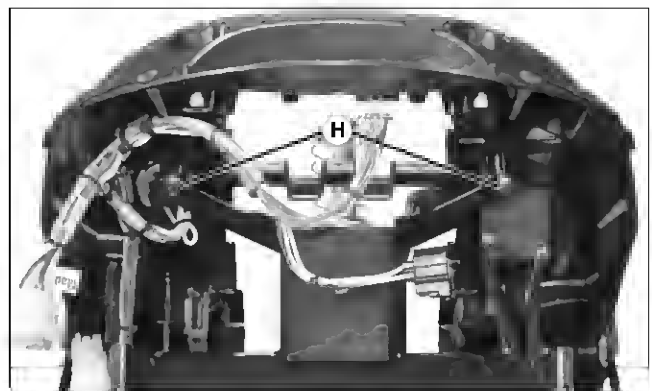
MX40422

5. Disconnect wiring connector (A) to main harness, and (B) to dash panel (hourmeter and warning lights). Squeeze tab on left side of connector (B) to unlock for removal.



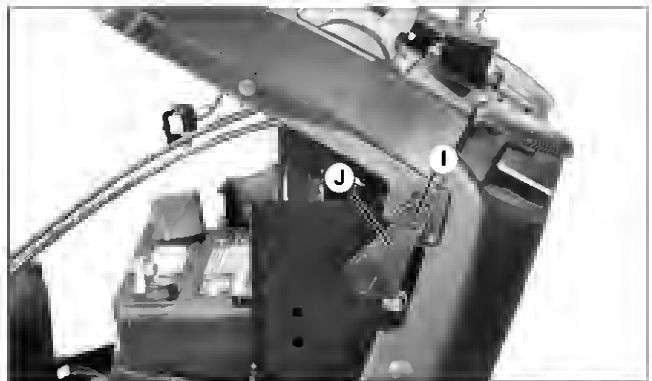
MX40423

6. Carefully flex the edges of the center panel (C) inward to unlock the tabs (D), starting at the front and working to the back, while tilting the center panel upward to remove.
7. Maneuver steering cover (E) around the tilt steering lever (F) and remove. Take care to not lose washer (G) on compression spring under steering cover.



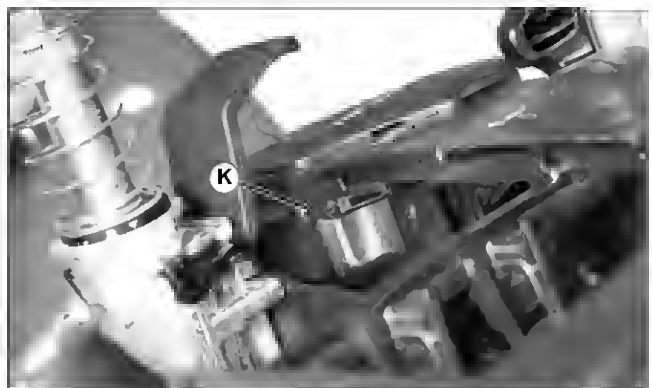
MX40424

8. Remove two cap screws (H) securing upper control panel to the steering pedestal.



MX40425

9. Remove the retaining screw (I) and hood latch (J) at each side of upper control panel.



MX40426

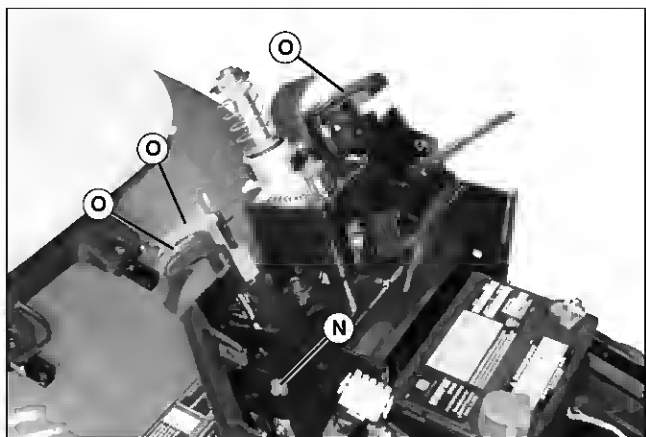
10. Disengage the locking tab (K) under the left rear corner of the upper control panel and lift the panel up and off of the steering pedestal. Disconnect throttle and choke cables at engine, if required.

## MISCELLANEOUS REPAIR



11. Remove the cap screw (L) on each closeout panel.

12. Unlock the front end of the close out panel from the frame. Carefully pull the rear of each closeout panel outward to disengage the rear tabs (M) from the lower control panel.



13. Loosen cap screw (N) at each side of the machine, securing a slotted tab from the lower control panel to the steering pedestal.

14. Lift the three linkage levers (O) to disengage them from slots in the top of the lower control panel. Tip the lower control panel back and remove from machine.

### Installation:

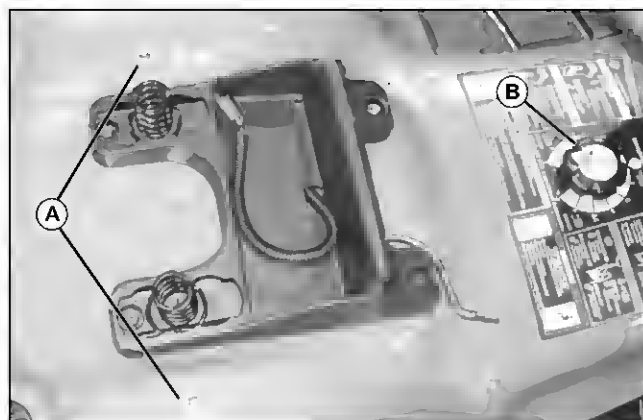
Installation is done in the reverse order of removal.

- Tighten steering wheel nut to **39 - 49 N•m (29 - 36 lb-ft)**.

## Fenderdeck Removal and Installation

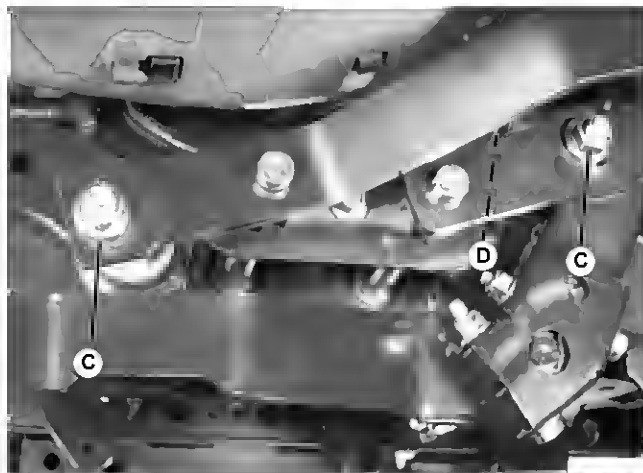
### Removal:

1. Park machine safely with park brake locked. See "Parking Safely" in the Safety section.
2. Raise hood. Disconnect negative battery terminal.
3. Disconnect seat switch wiring connector from seat switch.
4. Remove the seat pivot pin and seat.



5. Remove the two cap screws (A) from the top of the fender deck.

6. Remove the deck height adjustment knob (B).



7. Remove nuts (C) and forward and reverse pedals.
8. Remove nuts (D) securing each side of the foot deck to the support brackets.
9. Remove the fuel tank filler cap.
10. Remove fender deck, being careful to guide seat switch wiring through hole in bottom of platform.
11. Immediately install fuel cap, being sure to not allow dirt or other debris to enter fuel tank.

## MISCELLANEOUS REPAIR

### Installation:

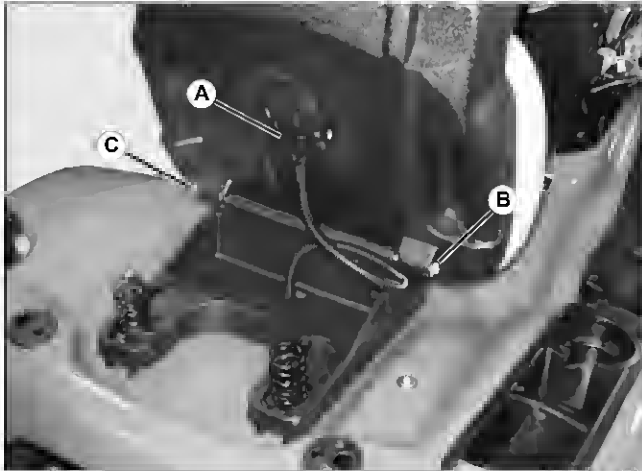
**Note:** Route wires and hoses in fuel tank slots to prevent pinching.

1. Installation is the reverse of removal.

### Seat and Support Removal and Installation

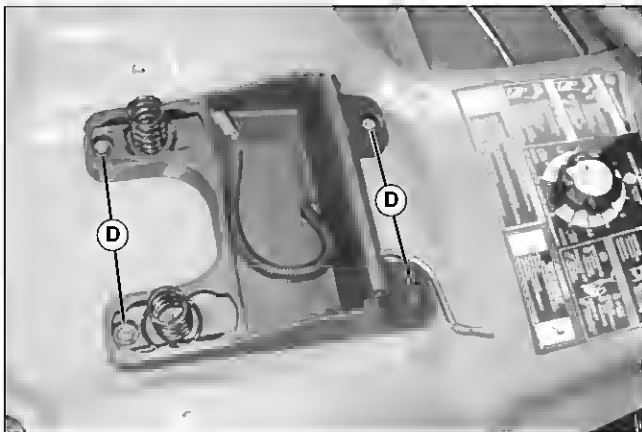
#### Removal:

1. Park machine safely with park brake locked. See "Parking Safely" in the Safety section.



MX36329

2. Lift seat. Disconnect wiring harness (A) from seat switch.
3. Remove the retaining ring (B) and pivot pin (C). Remove the seat.



MX36330

4. Remove four nuts (D).
5. Remove seat support.

#### Installation:

Installation is the reverse of removal.

### Fuel Tank Removal and Installation

#### Removal:

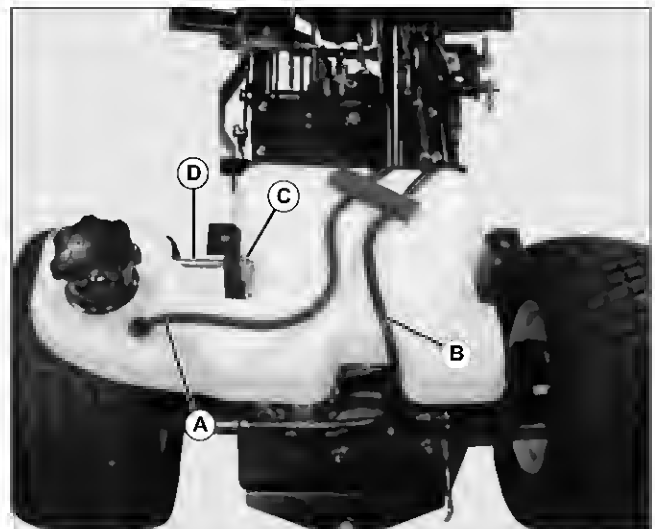
1. Park machine safely with park brake locked. See "Parking Safely" in the Safety section.
2. Raise hood. Disconnect negative battery terminal.



**Caution: Avoid Injury! Gasoline is explosive. Do not expose to open flame or spark. Serious injury can result. Store in a proper container. Wipe up any spills immediately.**

3. Disconnect fuel line at engine fuel pump and drain fuel from tank into an approved fuel storage container.
4. Remove fenderdeck assembly. See "Fenderdeck Removal and Installation" on page 566.

**Note:** For machines starting (SN 150001-) there is an added vent line from the fuel tank to the engine air intake.



MX36332

5. Remove fuel line (A) from fuel tank.
6. Machines SN 150001-: Remove vent line (not shown) from fuel tank.
7. Remove the fuel line and seat switch wiring harness (B) from the fuel tank.
8. Remove retaining nut (C) and fuel tank support rod (D).
9. Raise fuel tank from frame to remove.

#### Installation:

1. Lower fuel tank onto frame.
2. Install fuel tank support rod (D) and retaining nut (C).

**Note:** Route wires and hoses in fuel tank slots to prevent pinching.

## MISCELLANEOUS REPAIR

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3. Route the fuel line (A) and seat switch wiring harness (B) onto the fuel tank and secure in position.
4. Connect fuel line to fuel tank.
5. Machines SN 150001-: Connect vent line to fuel tank.
6. Install fenderdeck assembly. See "Fenderdeck Removal and Installation" on page 566.
7. Connect fuel line to engine fuel pump, and fill fuel tank.
8. Connect negative (-) battery cable.



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